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Water Quality Management Plan: Campbell County, Johnson County, Sheridan County (Wyoming)

Powder River Areawide Planning Organization
Sheridan, WY

Prepared for

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WATER QUALITY MANAGEMENT PLAN:

- CAMPBELL COUNTY
- JOHNSON COUNTY
- SHERIDAN COUNTY

PREPARED BY
THE POWDER RIVER AREAWIDE PLANNING ORGANIZATION

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The Powder River Areawide Planning Organization (PRAPO) was designated by the Governor of Wyoming to administer a federal grant for areawide waste treatment planning funded under Section 208 of the 1972 Federal Water Pollution Control Act Amendments. The major study area covered Campbell, Johnson and Sheridan Counties in Wyoming. Primary focuses of the study included 1) potential water pollution from mined land, 2) water quality problems pertaining to residential growth in unincorporated communities and in rural portions of the counties, especially contaminants leaching out of septic tank systems, 3) assessment of water quality as affected by waste treatment facilities in the 3-county area, and 4) potential pollution problems associated with agricultural activities. The overall study goal for the 3-county area was the improvement and maintenance of water quality at a point compatible with present uses and insurance of conformance with Wyoming's Water Quality Standards.

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FOR
CAMPBELL COUNTY, JOHNSON COUNTY AND SHERIDAN COUNTY

Prepared by
The Powder River Areawide
Planning Organization

with
technical assistance provided
by
Oblinger-Smith Corporation
Denver, Colorado

assisted by
TSP Wyoming
Sheridan, Wyoming

Camp, Dresser, McKee, Inc.
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August, 1978

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EXECUTIVE SUMMARY

Water Quality Goals

The 1972 Federal Water Pollution Act Amendments established national water quality goals and specific implementation procedures and schedules to achieve these goals. The overall goal of the Act is to "restore and maintain the chemical, physical, and biological integrity of the nation's waters." To achieve this objective, "it is the national goal that wherever attainable an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water be achieved by July 1, 1983." The purpose of this planning process was to systematically evaluate alternative means of achieving water quality goals and formulate a plan that could be implemented by agencies identified during the program.

Areawide waste treatment planning integrates various federal pollution abatement requirements (including municipal, industrial, residual wastes, runoff, and groundwater pollution abatement) and places a responsibility for planning and implementing these requirements with local, regional and state agencies.

Organization of PRAPO

In order to undertake this effort, the Powder River Areawide Planning Organization (PRAPO) was designated by the governor of Wyoming to administer a federal grant for areawide waste treatment planning funded under Section 208 of the 1972 Federal Water Pollution Act Amendments. PRAPO consists of executive board members representing all incorporated municipalities and the County governments of Campbell, Johnson, and Sheridan Counties. On June 13, 1975, an Environmental Protection Agency (EPA) grant was awarded to PRAPO and work was initiated on the project on August 11, 1975.

Major Study Concerns

The major study areas of concern included: 1) potential water pollution from mined land; 2) water quality problems pertaining to residential growth in unincorporated communities and in rural portions of the counties focusing on the problem of contaminants leaching out of septic tank systems; 3) assessment of water quality pertaining to waste treatment facilities in the three county area; and 4) potential pollution problems associated from agircultural activities. The overall study goal for the three county included the improvement and maintenance of water quality at a point compatible with present uses and insurance of comformance with Wyoming's Water Quality Standards.

Future Development Trends

In order to forecast future water quality problems, it is important to analyze existing population and development trends in the counties as well as project these trends forward for the twenty-year planning period. Population projections were prepared by a number of study participants. All projections indicate that the population in all three counties will more than double by the year 2000 primarily provided by the impetus of future energy extraction/production in the three county area. With these population increases, all of the urban areas in the three counties will increase with Gillette and Sheridan recording the greatest amount of population and new development in the three county area. Due to mining extraction/production activities there will also be considerable pressure to develop rural land for residential uses in Sheridan and Campbell Counties.

Coal Development

Campbell County contains 49 percent of Wyoming's coal resources and will experience a great amount of coal extraction in the county over the next twenty to sixty years. Existing and future mining operations will be focused in the north portions of Sheridan County near the Wyoming, Montana state line and mining activities in Johnson County will probably be located near the Lake DeSmet area north of Buffalo. It is a possibility that Texaco may construct a coal gasification plant in the Lake DeSmet area. In the near future a coal fired electric generation plant will be in operation five miles east of Gillette.

Recreational Development

As population increases in the three counties, there will be a tremendous increase in recreation in the Bighorn National Forest west of Sheridan and Buffalo. Specifically, recreation areas will be greatly impacted from increased usage which must be balanced with the development of grazing areas, lumber products, minerals and water resources. It is imperative that the variety of natural resources and the usage of forested areas encourages preservation of this natural resource.

Agricultural Activities

Historically, agricultural activities have provided the major key economic support in the three counties, and will continue to provide a strong economic support for the three counties. Campbell County contains the greatest amount of crop land farming with only a small amount occurring in irrigated farming. Sheridan and Johnson Counties respectively contain 60,801 acres and 45,133 acres of irrigated crop land. The goals of the three counties are to protect their agricultural economic base and to discourage prime irrigated agricultural lands from becoming developed for urban purposes.

Land Use - Water Quality Relationships

Land and water resources are totally interrelated and maintain direct impact on one another as well as on economic development. Therefore, water quality management requires land use planning in conjunction with all elements of the planning process. Land use/water quality relationships become particularly focused in urban development areas. Pollution sources occur from urban runoff, unpaved roads, development in flood plains, construction activities, solid waste disposal and from subdivision development and mobile home parks which do not contain adequate sewage disposal systems.

Summary of Major Water Quality Problems

In order to facilitate the water quality analysis in the three county area, the major streams were divided into segments of varying lengths. The analysis was conducted over 27 segments utilizing 158 water quality stations to evaluate the segments.

The most important hydrologic factor in the three county area is the variation in water avaliability between the eastern and western portions of the study area. Sheridan and Johnson counties receive surface run off from accumulated snow pack in the Bighorn Mountains. Streams are generally clear and cold and satisfy most water demands in the two county area, including providing municipal water for Sheridan and Buffalo. On the other hand, surface waters in Campbell County are practically nonexistent. Municipal as well as domestic demands are met by ground water in Campbell County.

Based on the water quality analysis the most pressing water problems appear to be the following: 1)In relation to point source pollution, it appears that dissolved oxygen concentrations will probably be maintained at acceptable levels by applying 1977 standards. However, the recommended sewage treatment alternatives for Buffalo and Sheridan, as they now stand, will probably be incapable of reducing ammonia concentrations below non-toxic levels in Clear Creek and Goose Creek. The two cities, the Environmental Protection Agency, the

Wyoming Department of Environmental Quality and project consultants are now working to develop a solution to these problems. 2) Potential salinity problems exist in Prairie Dog Creek, the Middle and North Forks of Powder River, Crazy Woman Creek and Clear Creek if TDS levels in these drainages were to record any consistent sharp increases. Little Powder River, Salt Creek, South Fork of Powder River and Mainstem of Powder River between Sussex and Arvada all have TDS levels which would impair irrigated agriculture in those drainages; however, very little irrigated agriculture occurs in those drainage areas. 3) In relationship to forested lands, it appears that potentially the greatest water quality problems will be from erosion, activities on forest land, and potential water quality degradation from increased recreational use in forested areas. Water quality degradation may also occur from over grazing and timbering. 4) Due to an increase in residential growth in unincorporated areas and unincorporated communities, many problems have occurred from contaminants leaching out of septic tank systems. In the future, ineffective septic systems may lead to greater contamination of surface waters as well as groundwater quality in various development areas. 5) With increased mining in the three-county area, there will be greater potential for water quality degradation occurring from mining operations. Water quality problems will occur from sedimentation, disturbance of aquifers, and the introduction of saline or toxic materials into the aquifers.

In reviewing stream segments for their ability to meet the 1983 fishable-swimmable criteria, it was necessary to consider all stream segments, whether or not they were able to hydraulically support those uses.

The following stream segments will be unable to meet 1983 fishable-swimmable criteria because of natural sources of pollution;

Little Powder River
Mainstem Powder River near Arvada
South Fork Powder River

Trace metals in the Little Powder River, Mainstem Powder River and South Fork Powder River, as well as periodically low dissolved oxygen levels in the Mainstem Powder River, will prevent these stream segments from meeting the 1983 goals.

The following stream segments will be unable to meet 1983 fishable-swimmable criteria, unless action is taken to eliminate man-caused sources of pollution:

Goose Creek below Sheridan
Clear Creek below Buffalo
Stonepile-Donkey Creek below Gillette

These segments presently will not meet the 1983 goals because of excessive levels of ammonia and fecal coliform bacteria. Upgrading of sewage treatment facilities in Sheridan, Buffalo and Gillette is required to eliminate these sources of pollution.

Little Goose Creek below its confluence with McCormick Creek and Big Goose Creek from above Sheridan to its confluence with Little Goose Creek have also recorded high numbers of coliform bacteria. Not enough data have been collected in these segments, however, to determine whether they are unable to meet the 1983 criteria at this time.

Meeting of Water Quality Standards

When the water standards proposed by the Department of Environmental Quality become finalized, they should prove sufficient to effectively protect Wyoming's waters if accompanied by satisfactory enforcement and planning. The proposed standards contain language dealing with salinity considerations. If backed by effective analysis and enforcement, these should prove sufficient to address these problems. In terms of the other parameters of consideration, the proposed water quality standards appear to adequately address potential problem areas.

A major change in the proposed standards calls for expansion of stream classifications from three to four, with the new Class I streams being those of unique value which will be maintained at their existing quality. Other changes include the establishment of specific limits for unionized ammonia and chlorine in Class II and III waters, as well as expansion of the number of streams which must meet primary contact recreation limits for fecal coliform bacteria.

In the 303e basin plan for Northeast Wyoming, Goose Creek was designated as effluent limited for its entire length and Clear Creek was listed as doubtful subject to further analysis. Based upon simulation modeling, it appears as if both streams can meet water quality standards for dissolved oxygen and coliform with properly constructed and operating secondary waste treatment facilities. Within the Goose Creek drainage this effort will also require that illegal septic tank discharges be eliminated. In both stream systems it appears unlikely that secondary treatment will remove sufficient ammonia to prevent toxic concentrations in receiving streams at the design flow ($Q_{7,10}$). In each instance, toxic concentrations could be observed in the reaches immediately downstream of the outfalls. Although this has occurred, it is recommended that Goose and Clear Creeks be considered effluent limited subject to additional analyses at a date when facilities construction is completed and operational.

Water Quality Related to Solid Waste Management and Air Quality

It is believed that there are no siginificant water pollution problems occurring in land fill site areas in the three county area. However, all areas surrounding the land fills should be observed and monitored during run off events to determine whether there is any possibility of contaminants reaching surface waters.

Also at the present there does not seem to be any conflicts between air quality maintenance planning and water quality management planning in the study area.

Non-Point Source Pollution Assessment

The major potential non-point pollution sources in the three counties originate from urban run off, mineral extraction, forest land activities and urban types of development in rural areas. Additional assessment should be undertaken to determine whether agriculture is or is not a significant pollutant source.

The major pollution sources associated with mineral exploration include erosion from disturbed surface areas surrounding drilled areas,from aquifer degradation associated with the use of drilling fluids and improper methods employed in drilling. The pollution potentials associated with the initial mining phase include, sedimentation, salinity and the possible release of toxic elements previously locked in underlying strata.

The activities associated with the mining phase of mine operations that possess the most severe water pollution potentials are continued road building and maintenance, continued stream channelization, continued stripping and storage, accelerated use of sanitary facilities, and any procedures necessary to prepare the coal for shipping at load out facilities.

During the post-mining phase, water pollution may occur from sedimentation and salinity in connection with storage areas and closed basins. There is also the possible creation of highly toxic ground water in reclaimed areas.

After utilization of specific best management practices to control water pollution during mining activities, it is recommended that a formal water resource evaluation be undertaken and reported for specific mining efforts in the three county area.

This evaluation should include the acquisition of necessary data required for the program, the formulation of pollution control plans and periodic and thorough inspections of each mining effort.

The primary goal is the establishment of a programmatic approach to water pollution assessment and control for which various levels of government, mining companies and concerned citizenry could utilize to maintain or improve water quality.

Six components of forest land activities were identified as having the greatest water pollution potential in the forested lands of the three county area. These included: 1) Recreation, 2) Silviculture, 3) Livestock and wildlife management, 4) Mineral development, 5) Transportation development, and 6) Fire and post-fire management.

Virtually all accessible portions of the forested lands in Johnson, Sheridan and Campbell counties are utilized to various degrees for recreational activities, such as camping, picnicking, hunting, fishing, hiking, and recreational vehicle driving. Increased bacterological and erosion/sedimentation contamination may result from recreational activities. Resorts, summer home groups, special-use camps and popular campgrounds potentially contribute to bacterological contamination of streams and groundwater through direct discharge and septic tank leakage.

Water quality monitoring in several forested areas in the past few years indicates that very little or no water pollution is occurring from recreation activities at the present time.

In relationship to silvicultural activities, sedimentation, chemical alteration, and debris accumulation are considered the prime potential pollutant sources originating directly from this activity.

Bacterological contamination from wildlife and livestock wastes is a major concern in the Bighorn National Forest watershed. Soil compaction and erosive action by water can be increased due to lack of ground cover and increased overland flow of water. Increased runoff makes these areas highly susceptable to sedimentation and erosion.

Full scale mineral development on forested lands in the study area has not taken place due to location of profitable deposits in other areas with easier access. If these materials are extracted in forested areas, sedimentation and dissolved solids may be the main pollution source related to this activity.

Erosion and sedimentation comprise the major potential pollutants with the construction of highways and improved roads in forested areas. Chemical and petroleum waste drainage, if not properly controlled during road construction, could create problems with the aquatic habitat of streams.

Forest burned areas may provide residue and chemical sources for water quality degradation. Also, burned areas are susceptible to erosion due to the destruction of ground cover. In order to control water quality degradation in forested areas, future management and planning efforts should be centered around Federal Unit plans and state management programs specific to the particular agency administering the forested lands.

Six stream segments in the study area, Prairie Dog Creek, the Powder River, Clear Creek, Crazy Woman Creek, Salt Creek, and the South Fork of the Powder River record either immediate or potential salinity problems. Although limited data were available to describe the water quality in Prairie Dog Creek, it appears as if the most potentially severe water quality problem is salinity present in the lower reaches of the drainage. The concentrations observed caused sharp increases in the salinity levels of the mainstem of the Tongue River below the Prairie Dog Creek Confluence. Sources of salinity in this drainage are primarily natural in origin.

Salinity in the Powder River is essentially a function of the salinity contributions of its tributaries. The contributions of Salt Creek and South Fork cause the mainstem concentrations to increase while Crazy Woman Creek and Clear Creek contributions have the opposite effect. Mean salinity concentrations in Clear Creek are below 700 mg/l. However, occasional peaks during late summer months reach levels which may prove detrimental to irrigation use if prolonged over extended periods of time. Irrigation exists throughout the entire length of the drainage and could possibly contribute up to 28 percent of the salinity load during the irrigation season.

Salinity concentrations on Crazy Woman Creek average over 1100 mg/l. Upper reaches of the drainage, near the confluence of the forks, contain 25 percent to 40 percent saline and alkaline soils. This area also contains most of the irrigated lands in the drainage. A possible 26 percent of the salinity load during the irrigation season may be caused by irrigation.

Salt Creek provides 26 percent of the total salt load in the Powder River at the State line. Except during runoff periods, the entire salt load in the creek is attributable to point source discharges from oil well treaters. Irrigation is almost non-existent in the drainage.

The South Fork Powder River maintains very high salinity concentrations which are primarily attributable to saline geology and soils. Point source discharges account for about 14 percent of the salt load in the drainage. Irrigation use of the waters is negligible.

The salinity levels in the Tongue River and Powder River drainage do not appear to be presently affecting the beneficial uses of waters in the State.

If the need for salinity control programs exists in the future, four general types of management programs are available to control salinity in these and other drainages; they include:

1. Implementation of on-site control programs for new development in the drainage.
2. Implementation of retroactive on-site control program for existing land uses in the drainage.
3. Establish salt allocation systems where an allowable basin-wide loading is determined.
4. Decrease salt discharge to a drainage by consumptive use of all or part of a tributary flow or flows.

Implementation of specific control programs should be left to those agencies with mandated responsibility. Irrigation programs would be implemented by the local Conservation Districts with technical assistance from the Soil Conservation Service and Soil Conservation Commission. Water resource program controls will be implemented by the State Engineer's Office and the Board of Control and the Water Quality Division of the Department of Environmental Quality. Salinity occurring from mining activities would be controlled by the Land and Water Quality Divisions of the Department of Environmental Quality at the state level and by the Bureau of Land Management and United States Geological Survey at the federal level.

Most urban runoff pollution arises from street surface contamination including: 1) Pavement decomposition 2) Pollutants from motor vehicles, and 3) Contaminants from vegetation and runoff from adjacent land areas.

Study data were not sufficient to determine overall and long range impacts of storm water runoff in Goose Creek and Clear Creek. Generally speaking, minimal impact was observed in both Creeks from study runoff samples. Storm drains along Goose Creek contained high concentrations of suspended solids and total dissolved solids. However, down stream concentrations were lower probably due to the processes of dilution and sedimentation. A higher concentration of nitrates and phosphates were also observed at Sheridan. Snowmelt from Buffalo carried into Clear Creek also contained high concentrations of suspended solids. The increase in total dissolved solids can almost entirely be attributed to road salts. Similar problems and patterns were also observed at Gillette in Donkey Creek. Since this stream is epheremal in character, water pollution from urban runoff is probably important only during flood stages of the creek.

Techniques to reduce urban storm runoff pollution would be constructural land management techniques (i.e., improved surface sanitation, chemical use control and better urban planning in new housing districts).

Highway and road construction projects consist of high risk activities with regard to their potential for contributing sediments and other pollutants to surface and groundwaters in Wyoming. To a large extent, good highway design practices protect water quality.

Since the Wyoming State Highway Department conducts the largest road construction program in the state, this department in conjunction with the Department of Environmental Quality has developed a state highway construction best management practices process, which outlines a procedure to accomplish construction pollution abatement at the state level.

Adherences to this procedure will assure that the planning, design, construction and maintenance of highways will meet water quality goals and standards.

The use of on-site disposal systems in the three county area is basically limited to the standard septic tank and leach field system. Some use is also made of aerobic tanks for solids removal in conjunction with the standard leach field.

Utilization of on-site disposal systems provides for a number of potential pollution problems which must be recognized and evaluated. These problems consist of groundwater pollution, leach field failure, non-point stream pollution and septage disposal.

A major recommendation concerning on-site disposal systems is that the counties should adopt on-site disposal regulations which would assure proper site selection, construction and maintenance of on-site disposal systems.

Point Source Assessment

Public Law 92-500 provides that the analysis of waste treatment alternatives must include an evaluation of the following: 1) Regional solutions. 2) Alternative waste treatment methods, or 3) No action. Regional solutions for waste treatment needs of communities in the three counties are not feasible due to geographic location and distance between communities. Each of the plans for the incorporated areas analyzed alternative treatment methods, provided an environmental assessment, selected an alternative treatment method and preliminarily designed and costed each facility.

Six wastewater management systems were analyzed for improvement of the Buffalo wastewater treatment facility. Of these six, the selected alternative included improvements to the system described as an aerated lagoon system. This recommended alternative was phased into a 3 stage construction program.

Five basic alternative wastewater treatment methods were considered for the Town of Clearmont. It was recommended that Clearmont proceed with implementating of a plan to upgrade the existing waste water facility to provide a 3-cell aerated lagoon.

Five basic alternative wastewater treatment methods were also considered for the Town of Dayton. The recommended alternative was to upgrade existing wastewater treatment facilities to provide a 3-cell aerated lagoon over a two stage time frame.

Seven wastewater treatment processes and improvements were analyzed for upgrading the Gillette waste treatment facility. Based on these analyses, it was recommended that the existing activated sludge plant should be improved and upgraded.

Five alternative waste treatment alternatives were analyzed for Kaycee including the conventional stablization pond, aerated lagoon, extended aeration plant, land application and control discharge pond. It was recommended that the Town continue to utilize and upgrade its existing waste treatment facilities and provide a 3-cell aerated lagoon.

Five treatment alternatives were also considered for the Town of Ranchester. Of the five alternatives considered, the aerated lagoon was recommended as the most cost effective alternative.

The Sheridan facility plan addressed two basic processes for the improvement of wastewater treatment including the trickling filter system and eight alternatives were considered related to the construction of a new activated sludge system. The recommended alternative for the City of Sheridan consisted of, upgrading the present unit treatment process and converting the present trickling filter process to the activated sludge method of treatment. It was also recommended that a infiltration-inflow correction program be undertaken to improve the existing collection system.

The unincorporated communities of Big Horn and Story maintain no central waste water facilities collection or treatment systems and depend entirely on private disposal systems such as septic tanks and leach fields. These communities were analyzed utilizing five basic methods for waste water treatment as well as a sixth alternative defined as no action, which consisted of the continuing use of privately owned waste disposal systems. The evaluation for both communities indicated that recognizing environmental and social considerations, the most cost effective means of meeting the established water quality objectives was to upgrade the existing private systems and control the construction of new systems in order to assure compliance with water quality standards.

Wastewater collection system trunk line studies were also undertaken during the course of the water quality management program for Buffalo and Sheridan. These analyses indicated that Buffalo should procede with a program of constructing a future service area trunk line system utilizing maximum use of existing facilities. The recommendation for Sheridan indicated that the first step was to initiate a program of infiltration-inflow rehabilitation, and a second step recommended that the City procede to develop a basic trunk line system.

Designation of Management Agencies

One of the end products of this phase of the water quality management planning process for the three county area is to recommend the designation of management agencies to implement the Plan. Management agencies should include state and local agencies as well as federal agencies, due to the fact that there are major federal land holdings in the Powder River area. It is essential that the roles of federal agencies in implementing the plan are carefully coordinated with the roles of local and state designated agencies. It should also be recognized that the State of Wyoming maintains a regulatory role relative to requiring federal agencies to meet state water quality standards and best management practices.

Five general criteria were applied in the development of recommendations for irsitutional arrangements for management of water quality in the three county area. These criteria included: 1) Authority and capability, 2) Acceptability, 3) Accountability, 4) Efficiency. and 5) Equity

In reviewing possible alternative areawide institutional management arrangements, thirteen subcategories of alternative institutional structures were analyzed. In reviewing and analyzing these alternatives it was recommended that the Wyoming Department of Environmental Quality be delegated the overall responsibility, supervision, coordination and continued planning role in the three county area. However, it may be beneficial for PRAPO or an advisory body to continue in an advisory capacity at the local level to assist the Department in this continuing planning and implementation process.

At the federal level it is recommended that the Bureau of Land Management and the United States Forest Service be designated as management agencies pertaining to agricultural and grazing activities, silvicultural activities and mining activities for controlling non-point source pollution on federal lands under their respective jurisdictions. The only exception to this is that the Wyoming Department of Environmental Quality should be designated as the management agency for surface coal mining operations on both federal and private lands based on the adoption of the Cooperative Agreement between the State of Wyoming and the United States Department of the Interior for the Enforcement and Administration of Surface Coal Mine Regulation Standards.

The Environmental Protection Agency should provide technical assistance to these designated federal agencies and their activities on federal lands related to non-point pollution sources. In addition, the Environmental Protection Agency should provide funding for planning and construction of general public wastewater systems in incorporated and unincorporated areas.

At the state level, the Department of Environmental Quality and its respective divisions should be designated as the basic management agency for water pollution control in the three county area. The only exceptions to this at the state level is the recommendation that the local conservation districts in cooperation with the Wyoming State Conservation Commission be designated as the management agency related to water pollution programs pertaining to agricultural and grazing activities on non-federal lands. The State Forestry should be designated as the management agency pertaining to silvicultural activities on state and private lands and the State Engineers' office should manage activities related to hydrologic modifications. Please refer to Table 87 on page 261 for additional detail on recommended management agencies.

At the local level, respective counties should be designated to manage on-site sanitary waste disposal[1], residual waste disposal, and construction activities pertaining to their jurisdictions. The municipalities should be designated as management agencies pertaining to construction activities, urban run-off, operation and management of public waste water systems and residual waste disposal in their jurisdictions. In several instances individual water and sewer districts should be designated over the short range as management agencies for general public waste water systems in unincorporated areas. However, over the long range it is recommended that the several existing operating water and sewer districts would be served by appropriate municipalities. Subsequently, the management function should be undertaken at a later time by the respective municipalities involved. Sheridan County should consider the possibility of establishing a county-wide water and sewer district to assist in meeting the sanitary waste treatment needs in unincorporated areas in the future.

One recommendation among many is that the Department of Environmental Quality provide water quality staff in Sheridan to assist the three counties in implementation of the plan and to more ably permit the Department of Environmental Quality to perform all of their necessary functions.

As pertaining to the existing wastewater facility financial framework, direct county participation has not existed. However, the counties, through their public health and land use planning roles, have made a financial contribution in the regulatory area. State financial efforts have also been primarily limited to the regulatory area.

Local long-range wastewater facility planning, except for Buffalo, Sheridan, and Gillette, has previously been funded from federal sources. On the other hand, short-range planning (i.e., sewer line extensions) has been completely borne as a local cost. There is, as a result of the recent facilities planning effort, an expectation that construction of needed additional waste treatment facilities will be partially funded by the federal government. However, to date, only several local jurisdictions have received such grants.

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[1] DEQ cannot delegate the regulatory function pertaining to on-site disposal but can develop cooperative agreements with counties to implement a local program.

Past capital outlay funding has been accomplished by the incorporated entities through the creation of debt (revenue and general obligation bonding). In some cases, significant amounts of this debt remain to be paid. Operation and maintenance costs have been borne solely by the localities. In some cases these consist of user charges and in others the tax base has provided needed financing. In general, the utility concept of full-costing the service and obtaining needed revenues through charges based on use is not followed.

Financing is intertwined with the types of institutional arrangements finally agreed upon and implemented. Further, those financing techniques finally adopted must conform, in the case of federal grant-funded facilities, with the requirements imposed by federal law. It is important to realize that for those communities accepting federal construction grants, reliance on the ad valorem tax base for operation and maintenance costs will no longer be allowed. Further, some form of user charge system based on both sewage volume and amounts of pollutants (biochemical oxygen demand and suspended solids) will have to be adopted in order that the full amount of a federal grant may be received.

Based on the financial analysis, the following financial strategies and techniques should be considered:

1. Use of short-term (10 years or less) debt for phased facilities construction and long-term (20 years of more) debt otherwise.
2. Use of separate funds and full cost recovery user charges in larger municipalities.
3. State acceptance and bearing of costs of the monitoring, regulatory, and planning functions.
4. Local funding of land use and building code enforcement (presently utilized in some instances).
5. Use of the assessment district form of debt cost sharing in developed (or nearly developed) areas.
6. State and federal financing of non-point source controls.

Public Involvement

Public involvement activities must be maintained during the continuing planning process. Strong efforts are required to involve the public in implementation of various phases of the plan. The public must be made aware of the process and be involved in annual plan updates. They must be aware of their responsibilities in preserving the quality of the water in the area.

Chapter I

INTRODUCTION

BACKGROUND STATEMENT

The 1972 Federal Water Pollution Control Act Amendments established national water quality goals and specific implementation procedures and schedules to achieve these goals. Four planning requirements were outlined in the Act:

1. The provisions for the preparation of 20 year areawide waste treatment management plans by local regional planning agencies. Areawide planing produces local strategies for water quality improvement. This plan was prepared under the provisions of this Section.
2. The provisions for the development of a wastewater facilities plan leading to design and construction of a cost effective, environmentally sound municipal waste treatment facility. All construction grants and discharge permits must conform with this locally prepared 208 plan.
3. The provision for the development of an annual program plan by State Water Pollution Control Agencies. Progress in abating water pollution is checked against this plan on a semi-annual basis.
4. The provision for the preparation of overall water quality management plans for river basins by State Water Pollution Control Agencies. These plans provide the basis for priority lists for construction of wastewater treatment facilities.

Areawide waste treatment planning integrates various federal pollution abatement requirements (including municipal, industrial, residual wastes, runoff and groundwater pollution abatement) and places the responsibility for planning and implementing these requirements with local, regional, and state agencies.

The major purpose of waste treatment planning is to meet 1983 water quality goals by:

A. Developing a plan.
B. Selecting a management agency to implement the plan.
C. Demonstrating that the plan will allow the area to meet 1983 standards.

This planning effort concentrated on the most serious pollution problems over the two year study period. With annual plan updates and implementation of the Plan, water quality in the three counties should be maintained at present or higher levels.

PURPOSE AND OBJECTIVES OF WATER QUALITY MANAGEMENT PLANNING[1]

The overall objective of the Act is to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (Section 101(a)). To achieve this objective, "it is the national goal that wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water be achieved by July 1, 1983" (Section 101(a)(2)). To enable meeting the Act's objectives, "it is the national policy that areawide waste treatment management planning processes be developed and implemented to assure adequate control of sources of pollutants in each State" (Section 101(a)(5)).

The purpose of the planning process is to systematically evaluate alternative means of achieving water quality goals where obtainable and to formulate a plan that can be implemented by a 208 management agency. The planning process must integrate technical needs for pollution abatement and management arrangements capable of implementing the abatement measures, and provide for public participation in plan development.

The technical planning portion of the planning process involves identifying the priority water quality problems of the area, recognizing any constraints in dealing with the problems, and developing alternatives to achieve water quality goals.

Management planning, which concerns selection of a management agency or agencies and development of appropriate institutional arrangements for plan implementation, should be conducted concurrently and in coordination with technical planning. Management planning should identify water quality management problems, and analyze the capability of existing agencies and arrangements to carry out the regulatory and management requirements of Section 208.

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[1] Guidelines for Areawide Waste Treatment Management Planning, U.S. Environmental Protection Agency, p. 1-1 and 3-1.

Institutional problems, lack of authority, or lack of financial capacity for meeting Section 208 requirements should be identified. Alternative means to acquire proper authority, financial capacity and effective institutional arrangements for plan implementation should be developed. Finally, alternative management agency(s) and institutional arrangements should be evaluated and with subsequent selection of appropriate agencies and institutional arrangements.

Developing alternative technical and management plans and selection of an areawide waste treatment management plan require public participation throughout the planning process. Public participation and means for ensuring adequate participation are required at each stage in the planning process.

It is stressed throughout this planning and management process that local elected officials and agencies provide the leadership in directing the process and program due to the fact that they are major implementors of the Management Plan.

WORK PROGRAM REVIEW

Organization of PRAPO

The Powder River Areawide Planning Organization (PRAPO) was designated by the Governor of Wyoming to administer a federal grant for areawide waste treatment management planning funded under Section 208 of the 1972 Federal Water Pollution Control Act Amendments. Authority for the organization of PRAPO is provided under Wyoming Statutes Chapter 1, General Provisions, Section 9-18-7 "Local Governmental Units Empowered to Cooperate with Each Other and with the United States," and Chapter 21, Wyoming Joint Powers Act, which allows for the formation of areawide planning organizations.

Executive board members of the Powder River Areawide Planning Organization represent all incorporated municipalities and the County governments of Campbell County, Johnson County, and Sheridan County.

Work Program Efforts [1]

A total of $415,000 was allotted on April 4, 1975 by the Environmental Protection Agency to be used by the Powder River Areawide Planning Organization for water quality management planning. On June 13, 1975, the grant was awarded and work was initiated on the project on August 11, 1975.

The work program was divided into four principal sections. The first section dealt primarily with the need for new or updated municipal wastewater systems. The basic work elements for this section involved the preparation of wastewater treatment facilities plans for eight incorporated and unincorporated communities in the planning area. Authority for such planning comes from Section 201 of the 1972 Federal Water Pollution Control Act (FWPCA). Facility plans were prepared for the City of Gillette, the Towns of Clearmont, Dayton, Kaycee and Ranchester, and the unincorporated communities of Acme, Big Horn and Story. Future trunk line feasibility studies were also completed for the cities of Buffalo and Sheridan to aid in determining future growth patterns and needs. In Gillette, the lack of accurate drawings and related material left the City without proper knowledge of the present sewage collection system. An element of the study was to determine the present trunk lines in the City. The final work element within the engineering section of the program was the preparation of aerial maps for Gillette, Buffalo and Story. These maps have and will assist local governments in implementing water quality related land use controls.

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[1] Prepared from information developed by the staff of the Powder River Area Planning Organization.

All work elements within the engineering section of the work program, except for the Gillette facilities study and trunk line study, were undertaken by the consulting engineering firm of VTN Wyoming, Inc. The Gillette work elements were completed by Plains Engineering.

The University of Wyoming's Water Resources Research Institute (WRRI) was contracted by PRAPO to undertake the work elements of the second section of the work plan, concerning water quality determinations. This effort contained the core of the areawide planning program covering a wide variety of tasks encompassing the three-county area. A reconnaissance level monitoring program along the major stream drainages in the Powder River Basin was performed to locate water quality problem areas. A limited program pertaining to groundwater was also undertaken in the Story and South Sheridan areas.

A water quality data base was established utilizing the Wyoming Water Resources Data System at the Water Resources Research Institute. All surface and groundwater data were then combined into a water quality assessment of the Powder River Basin.

Along with this assessment, a number of specific work elements were performed. A water quality waste allocation model was used to evaluate the effects of municipal discharges on three streams in the planning areas to assist the State in determining discharge permit parameter levels for these streams. Drinking well monitoring programs were performed in areas of high septic tank density to determine the effects of high septic tank usage on private drinking water supplies.

A study of present water usage and estimated future water needs from surface and groundwater sources was conducted using the Powder River Economic Simulation Model adopted by the Water Resources Research Institute. In a cooperative effort with the U.S. Forest Service, WRRI and PRAPO conducted a water quality survey and monitoring program within the Bighorn National Forest. Utilizing these data and data supplied by the Forest Service, a report on water quality determination on forested lands in the planning area was prepared. WRRI also completed a monitoring program and report on urban runoff in Sheridan, Buffalo and Gillette. The Institute's final work element involved conducting a water quality monitoring program in mining areas and utilizing the data collected, and techniques developed for the control of mining pollution, to make recommendations for a program to control mining non-point pollution.

The Wyoming Highway Department, at the State level, prepared a report on highway and road construction best management practices. This report was developed to be utilized in the areawide plans as well as the statewide plan.

PRAPO staff, in addition to working with consultants, has prepared a report on on-site disposal use in the planning area. Along with this, the staff surveyed and reported on sites and the interrelationship of water quality with solid waste disposal and air quality maintenance.

The third section of work was involved primarily with land use considerations. These work elements were carried out in the three counties by the three respective county planning offices under contract with PRAPO. The work elements included inventories of existing planning and implementation activities, soils suitability, natural environmental conditions related to water quality, mobile home parks and other high density unincorporated growth areas. Population, economic, social, cultural, industrial and land use trends and growth characteristics were estimated for five, ten and twenty-year planning periods. Land use and water quality relationships were also investigated. These work elements were then combined to formulate alternative land use plans with an emphasis on water quality aspects.

The final phase of the work program involved utilizing the work elements from the first three sections of the work program to prepare a 208 plan which is capable of being implemented. This involved identifying and evaluating all public and private agencies or organizations concerned with water quality and their roles, responsibilities and capabilities of implementing the plan. Existing laws were reviewed and analyzed for the specific legal authority necessary to implement the plan. Necessary economic considerations to implement were evaluated. Alternatives were then developed and analyzed to determine impacts on water quality, reliability, costs, environmental effects, implementation feasibility and public acceptance.

Throughout the two year planning effort a public participation program was carried out to inform the public of efforts being undertaken to improve waters in the three-county area and to solicit public input to be utilized in the program.

REVIEW OF WORK EFFORT PRIORITIES

At the outset of the program, four major areas were considered to be the water quality management planning priorities in the three-county area. These four priorities are as follows:

1. Water pollution from mined lands;
2. Water quality problems pertaining to residential growth in unincorporated communities and in rural portions of the counties focusing on the problem of contaminants leaching out of septic tank systems;
3. The potential pollution problems associated from agricultural return flows and an assessment of the problem if present in the three-county area;
4. Assessment of water quality pertaining to waste treatment facilities in the three-county area.

As the study progressed over the two-year period, these work elements and considerations remained the important priorities for analyses and recommendations for the control of degradation of water quality in the three-county area. Other important water quality concerns analyzed during the program included water pollution from forested lands and urban runoff and the salinity problem occurring in several watershed areas.

Also during the course of the study, the total issue of non-point sources of pollution occurring from secondary growth impacts (i.e., construction of dwelling units in unincorporated areas and in rural areas) became an increaseingly important study priority. Lack of or less than adequate enforcement of non-point source controls potentially will lead to additional degradation of water quality in the streams in the counties.

In reviewing these water quality study priorities, the most important results of the total effort is the formulation of a systematic approach to water quality management in the study area.

PLANNING BOUNDARIES

The Executive Board of PRAPO consists of members representing all incorporated municipal governments and County governments within Campbell, Johnson and Sheridan Counties. Consequently the PRAPO planning area consists of the total area in Johnson, Campbell, and Sheridan Counties, and jurisdictions within.

Map 1 shows the location of these counties, with respect to the State of Wyoming and the United States. The most important physical landmarks in the counties consist of the BigHorn Mountain Range which forms the western boundary of the study area, and the Tongue and Powder River drainages which dissect the area. The largest economic and social centers consist of the incorporated municipal areas of Sheridan, Gillette, and Buffalo, which comprise the county seats of Sheridan, Campbell, and Johnson Counties, respectively.

The incorporated municipalities by County are as follows:

In Campbell County:

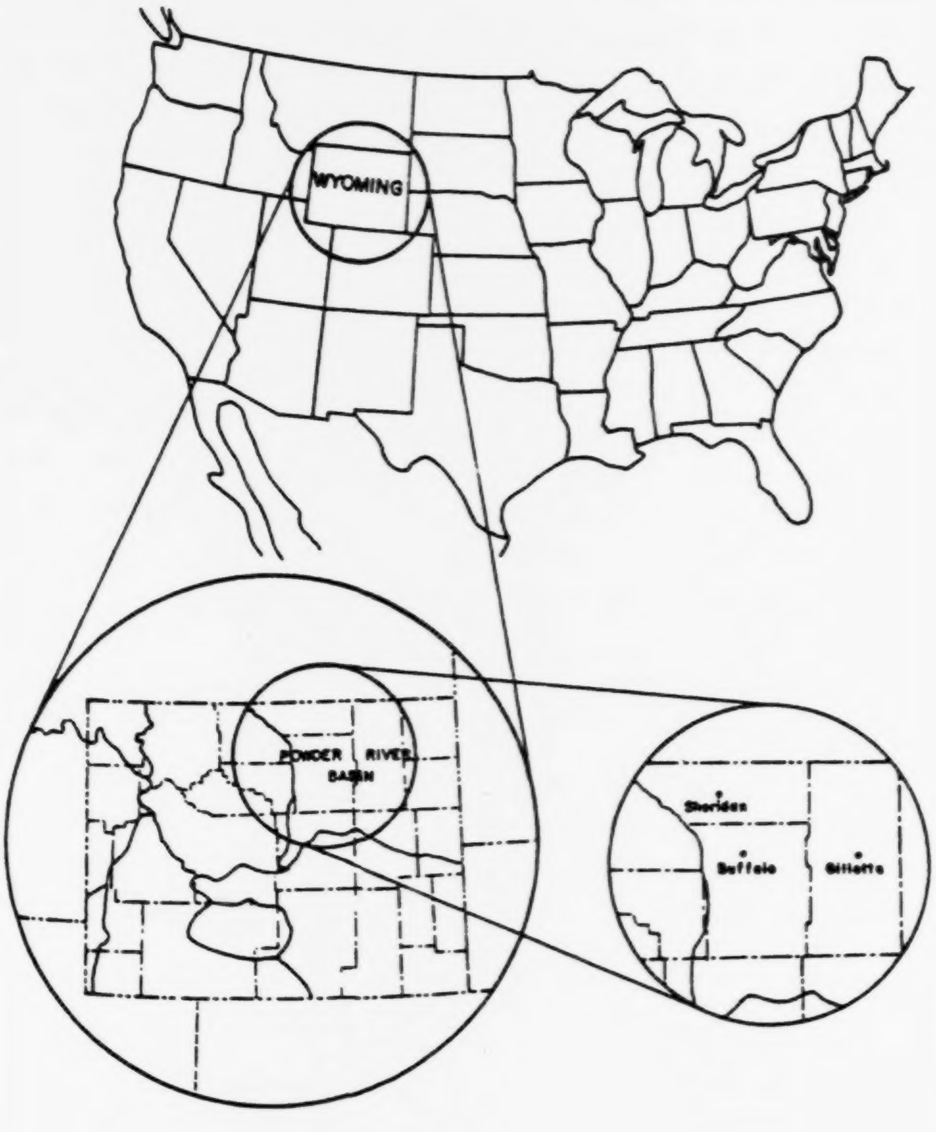
1. City of Gillette

In Johnson County:

1. City of Buffalo
2. Town of Kaycee

In Sheridan County:

1. City of Sheridan
2. Town of Dayton
3. Town of Ranchester
4. Town of Clearmont


WYOMING
POWDER RIVER
BASIN
Sheridan
Buffalo
Gillette

PRAPO LOCATION MAP

MAP 1

OVERALL WATER QUALITY GOALS FOR CAMPBELL, JOHNSON AND SHERIDAN COUNTIES

Within the framework of Section 208 of the Federal Pollution Control Act of 1972 (P.L. 92-500), the overall national water quality goals are "to achieve, wherever attainable, water quality which provides for the protection and propagation of fish, shellfish and wildlife, and recreation in and on the water." These are often referred to as the "fishable-swimmable" goals of the Act. Goals recommended for the three-county area include the improvement or maintenance of the area's water quality at a point compatible with present uses and insurance of conformance with Wyoming's Water Quality Standards. Unlike many other 208 planning areas, the PRAPO planning effort is primarily concerned with water quality maintenance in the three county area. Those stream reaches which require water quality improvement in order to meet these goals are identified in Chapter II. In most cases, the necessary regulations and/or programs are already in existence which could correct these problems. The data analyzed in Chapter II suggest that with the exception of a few site specific pollution problems, the area's water quality is good.

Other program goals include the formulation of pollution control management programs for specific activities or pollutant types expected to present additional problems in the future. The need for the following programs has been identified and was addressed in the total work program.

1. Salinity management;
2. Forested lands management;
3. Mined lands management;
4. Urban runoff management;
5. Waste treatment facilities management.

Chapter II

ANALYSIS OF EXISTING CONDITIONS, WATER QUALITY AND FORECASTS OF FUTURE IMPACTS

CURRENT AND PROJECTED POPULATION

Introduction

An analysis and projection of population for the three counties were undertaken by various study participants during the water quality planning program. Trends and projections were formulated in the individual facilities planning efforts, by the counties and by the Water Resources Research Institute in developing wasteload allocations and water demand projections for the three-county area. The projections were coordinated as closely as possible throughout the total planning program.

In reviewing these projections and the efforts in the program, it was decided to utilize target population projections prepared in the facilities plans due to the fact that projected capital construction costs and operating and management costs for facilities were based upon the population projections formulated in those studies. A review of population projections by study participants is shown in this section of the report.

At the present time, the State Department of Economic Planning and Development is in the process of initiating a program in conjunction with the counties to update population projections on a quarterly or semi-annual basis. It is very clear, due to the rapid expansion of the energy extraction and production industry, that population projections in these impacted areas are very difficult to predict for any extended period of time. In short, population analyses and projections must be undertaken on a short term periodic continuing basis.

Population Trends and Projections - Campbell County, Wyoming

The population of Campbell County increased at an average annual rate of 11.3 percent between 1960 and 1975. As of 1975, 45.6 percent of the population of the County was residing in locations outside the City of Gillette, with approximately 54.3 percent located within the City limits.

Much of the impetus for new population growth in Campbell County will be influenced by coal mining and related activities due to the occurrence of huge amounts of coal resources located in a north/south direction in the County near Gillette. The population projections shown in Table 1 take into consideration the potential energy development in the County. Although the target years varied somewhat by study participants, the population projections were based quite consistently upon an average of the high and low estimates prepared during the formulation of a detailed economic base study for the County.

TABLE 1

Population Projections - Campbell County, Wyoming

		Comprehensive Plan Projections		Facilities Plan Projections		WRRI Projections	
Jurisdiction	1976	1980	1990	1980	1997	1980	1997
Campbell County	20,620	33,500	46,325	--	--	24,861	55,212
Gillette[1]	15,720	26,500	37,430	26,560	40,000	19,143	44,169

[1] Urbanizing area

Sources: Analysis of the Economic Base and Growth Potentials 1976-1990, Gladstone Associates, assisted by Oblinger-Smith Corporation, p. 70.

EPA 201 Facilities Plan for the City of Gillette, Wyoming, Plains Engineering, p. IV-5

Population and Water Demand Projections 1982 and 1997, Water Resources Research Institute, p. 74.

Population Trends and Projections - Johnson County, Wyoming

Since 1930, Johnson County has sustained an overall increase in population through each decade except from 1940 to 1950. In this decade population in the County decreased by 5.5 percent. Most dramatically, Buffalo has recorded population increases since 1930. Kaycee also gained additional population each decade other than from 1960 to 1970 in which a slight decrease had occurred.

Johnson County, as well as Campbell and Sheridan Counties maintains a potential for rapid growth based on coal development within the County. The projections shown in Table 2 were formulated by various study participants, but all utilized estimates of future development levels based on best expectations of future events as determined by announced and anticipated economic activity, national and state energy demands, and other regional factors. Particularly the most significant impact from growth in Johnson County may be the development of synthetic coal processing (gasification and liquification).

TABLE 2
Population Projections - Johnson County, Wyoming

		Comprehensive Plan Projections		Facilities Plan Projections		WRRI Projections	
Jurisdiction	1976	1980	2000	1980	2000	1980	1997
Johnson County	6,590	10,370	14,000	--	--	10,011	23,399
Buffalo	4,200	6,700	10,600	6,500	17,513[1]	7,280	19,889
Kaycee	350	540	875	540	1,020	--	--

[1] 1995 projection

Sources: PRAPO, EPA 208 Wastewater Facility Planning, Johnson and Sheridan Counties 201 Facilities Plans - Interim Report, VTN Engineers, Planners, Surveyors, p. III-2.

Buffalo, Wyoming Wastewater Facility Plan, Step 1, VTN Engineers, Planners, Surveyors, p. IV-8.

Population and Water Demand Projections - 1982 and 1997, Water Resources Research Institute, p. 78.

Johnson County Land Use Plan, Buffalo-Johnson County Planning Office, p. 6.

This growth would particularly be focused at the Lake DeSmet area north of Buffalo. Texaco maintains extensive coal and water holdings in this area. In 1976, Texaco completed a major water diversion storage project on the lake.

If a gasification plant is constructed in that area, this will tremendously impact and accelerate the growth, particularly in the Buffalo area.

Recent oil and gas discoveries in southeast Johnson County and the possible initiation of a uranium operation in the Kaycee area may induce additional growth in the County. Large scale coal developments in Campbell and Sheridan Counties will also to a degree impact Johnson County. The population projections shown in Table 2 illustrate dramatic increases in population in the County as well as the two communities.

Although the projections prepared by these agencies incorporated potential energy developments that might be occurring in the Johnson County area, it should be noted that the population projections prepared in the Johnson County plan did not take into consideration the population increase that would be associated with a potential gasification plant.

Population Trends and Projections - Sheridan County, Wyoming

In 1976 it was estimated that Sheridan County contained a population of 20,800 persons, which amounted to the highest population ever recorded in the County. Although this is the highest recorded number of people living in the County, decreases were experienced from 1920 to 1930, and from 1950 to 1970. The City of Sheridan recorded population increases through the decades except for 1920 to 1930 and 1960 to 1970.

As shown in Table 3 , it is expected that the population will continue to increase basically due to the nation-wide energy crisis and the resultant demands for the increased production of domestic cost of fuel resources and location of these resources in Sheridan County, southern Montana, and adjacent Johnson and Campbell Counties. The population projections prepared in the Comprehensive Plan are based on average increases in population from 1970 to 1976. The Comprehensive Plan projections did not take into consideration mineral-related activities due to the fact that those figures were not available at the time the Comprehensive Plan was drafted. The facilities plan population projections for the City of Sheridan, however, reflected potential energy development increases in the north portions of the County.

TABLE 3

Population Projections - Sheridan County, Wyoming

Jurisdiction	1976	Comprehensive Plan Projections		Facilities Plan Projections		WRRI Projections	
		1980	2000	1980	2000	1980	1997
Sheridan County	20,800	22,734	32,584	--	--	26,033	47,428
Sheridan	13,200	14,763	22,583	16,652	26,325[1]	16,921	33,200
Clearmont	182	209	345	209	345	--	--
Dayton	550	654	1,170	655	1,170	--	--
Ranchester	420	550	1,260	560	1,260	--	--
Big Horn	386	510	1,130	510	1,130	--	--
Story	500	565	898	565	898	--	--
Acme	137	--	--	--	--	--	--

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[1] 1995 projection

Sources: A Comprehensive Plan for Sheridan County, Sheridan County Planning Commission, p. 37.

Sheridan Wyoming Wastewater Facility Plan - Step 1, VTN Engineers, Planners, Surveyors, p. 3-6.

A Population Study of Sheridan County,Wyoming, Sheridan Area Planning Agency, p. 28-A.

Powder River Areawide Planning Organization Population and Water Demand Projections 1982 and 1997, Water Resources Research Institute, p. 81.

PRAPO, EPA 208 Wastewater Facility Planning, Johnson and Sheridan Counties - 201 Facilities Plans, Interim Report, VTN Engineers, Planners, Surveyors, pp. V-2, VI-2, VII-2, VIII-2, IX-2.

EXISTING AND PROJECTED DEVELOPMENT PATTERNS

Urban Development and Future Service Areas

Campbell County

Campbell County and Gillette, the only urbanized municipality in Campbell County, are experiencing rapid growth due to the development of the coal extraction industry in the County. Employment and population growth in the County may more than double by 1990. It is expected that much of this growth will be in and near the urbanized area of Gillette and at urban densities. Approximately 10 to 20 percent of the growth may occur outside of the planning district surrounding Gillette. Consequently urban types of development have and will continue to occur near the location of the coal mining effort.

The major urban growth in the Gillette area is forecasted to locate south and southwest of the present developed area in and near the City of Gillette. This is based to a major degree, on the availability of land that can be provided sanitary sewer services connecting into the City of Gillette central system. Urban growth will also occur in other quadrants surrounding Gillette.

Residential growth will continue to consist of mobile home courts and conventional subdivisions. The general configuration of the growth and service area of Gillette is shown on Map 2, along with the secondary growth areas tending toward urban densities in other portions of the County. These secondary growth areas contain housing located near mining areas.

Johnson County

Based on population and economic projections, it appears that Johnson County and the City of Buffalo's growth may also more than double by year 2000 over 1976 levels. The greatest impetus to encourage growth in Johnson County will probably be the development of coal and water holdings in the Lake DeSmet area north of Buffalo.

Areas of urban concentration in Johnson County will continue to occur in Buffalo and Kaycee and near environs. It is anticipated that the largest amount of growth will occur in and contiguous to Buffalo. The second largest amount of growth will probably occur in and around the Kaycee area. It is a clear policy of the County that urban growth should be in and contiguous to these communities rather than in prime agricultural land areas and stream valleys.

There are growth pressures in the rural part of the County northwest of Buffalo between French and Rock Creeks. Other areas that are experiencing urban types of development are north of Buffalo and the area west of Buffalo in the Clear Creek Valley. In fact, the area west of Buffalo in the Clear Creek Valley has been identified by the County as an area of critical concern. It is imperative that this area continues to be protected as a source of Buffalo's municipal water supply.

As much as possible future urban land uses in the PRAPO area should be located in existing urban development areas.

Sheridan County

The County encompasses an area of 2,532 square miles. Of the 2,532 square miles, 28 percent (709 square miles) is under Federal ownership, 8.6 percent (217.7 square miles) is under state and local government ownership, and 63.4 percent (1,605.3 square miles) is under private ownership.

The urban areas in the County account for approximately 27,225 acres or 1.7 percent of the total land use in the County. This amount of land includes a number of acres of agricultural land at the present time, but the possibilities for urban development are very high in these areas.

It is estimated that 535 acres of land are occupied for residential uses in the rural areas of the County amounting to approximately .03 percent of the total acreage of Sheridan County.

Most of the commercial development has occurred in urban areas. Extraction of coal, oil, gas, gravel and scoria are the major industrial uses in rural Sheridan County. An area north and northeast of Sheridan contains a heavier concentration of this type of development than other areas in the County. Agriculture is the predominant use of land in Sheridan County.

All of the incorporated and unincorporated communities in Sheridan County are expected to experience increased population and land use development other than

Acme, which is a privately owned community. It is understood that the owners of Acme will not maintain residential living units in that area beyond the Autumn of 1977. The City of Sheridan will probably receive the greatest amount of urban growth in the County.

There has been and continues to be development in the rural parts of the County, particularly in the Little Goose and Big Goose Creek Valley floors. This type of urban growth at low densities in these areas could potentially promulgate a moderate water quality degradation problem with respect to the uncontrolled construction of individual wells and septic systems. These growth areas are shown on Map 2.

Mineral Resources and Mining Development

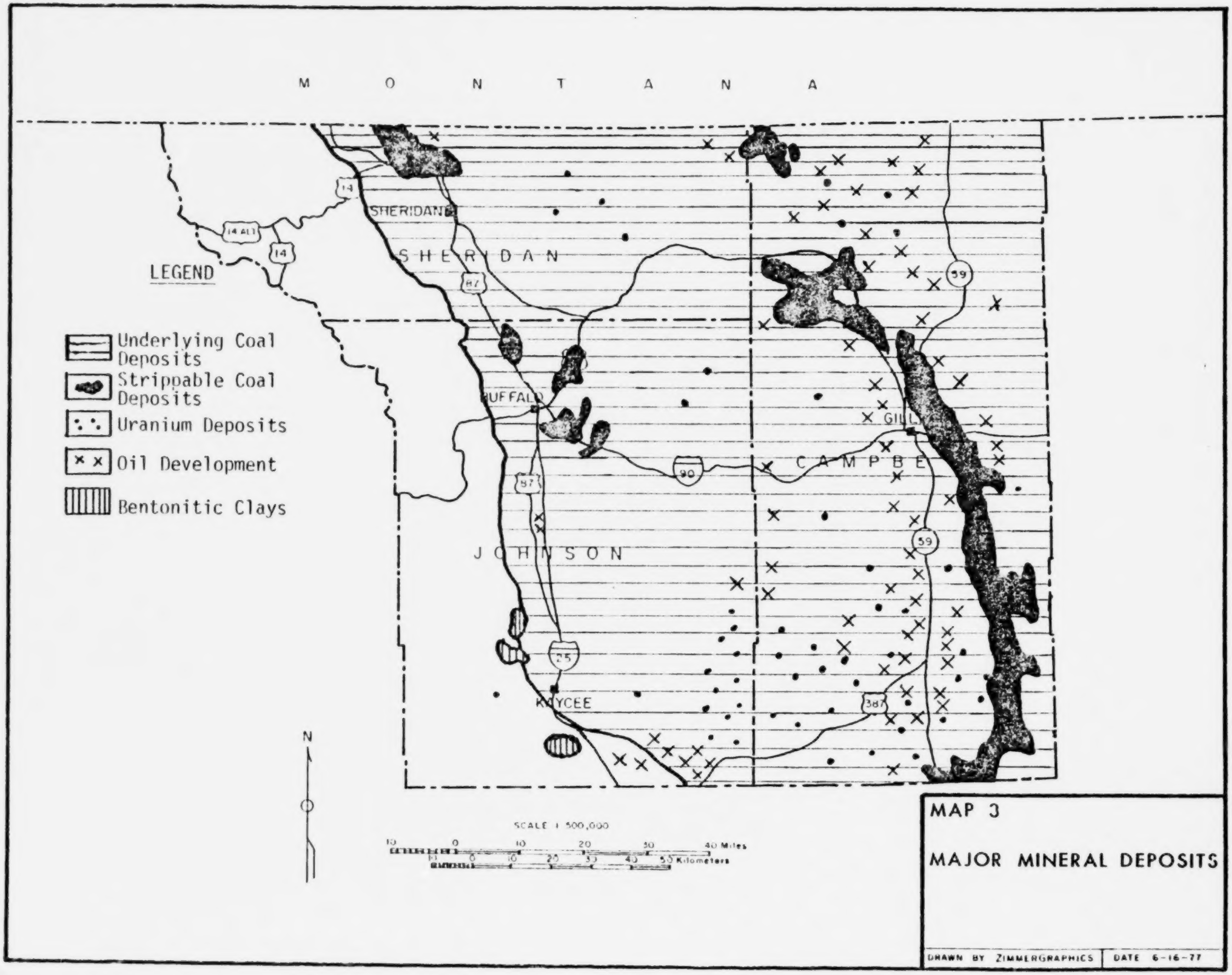
The major mineral deposits in the three-county area are shown on Map 3. Although continued development of all the resources shown is expected, a surface extraction of strippable coal deposits appears to offer the most potential for development. Map 4 illustrates the location of possible coal mining operations in the three counties by 1985.

Campbell County

Mines currently in production in Campbell County include: Wyodak, Rawhide, South Belle Ayr, and Cordero.

The identifiable coal reserves in Campbell County account for 49 percent of Wyoming's coal resources and 5.5 percent of the nation's coal reserves. The advantages of low sulphur coal found in Campbell County are that it is: 1) strippable with 23 billion tons under less than 200 feet of overburden; and 2) it is low in sulphur content. The full magnitude of coal development in the County is uncertain at this time. It appears that mining could occur for a period of not less than 60 years, and potentially up to 250 years, before recoverable resources are depleted.

Campbell County presently produces 25 percent of the state's production of natural gas and oil. Oil and natural gas reserves in Campbell County are not as extensive as coal resources. As of 1975 oil and natural gas reserves amounted to only 2 to 3 percent of the nation's reserves.


MONTANA
SHERIDAN
JOHNSON
CAMPBE
SHERIDAN
BUFFALO
GILL
KAYCEE
14
14 ALT
14
87
87
90
25
59
59
387
LEGEND
Underlying Coal Deposits
Strippable Coal Deposits
Uranium Deposits
Oil Development
Bentonitic Clays
N
SCALE 1:500,000
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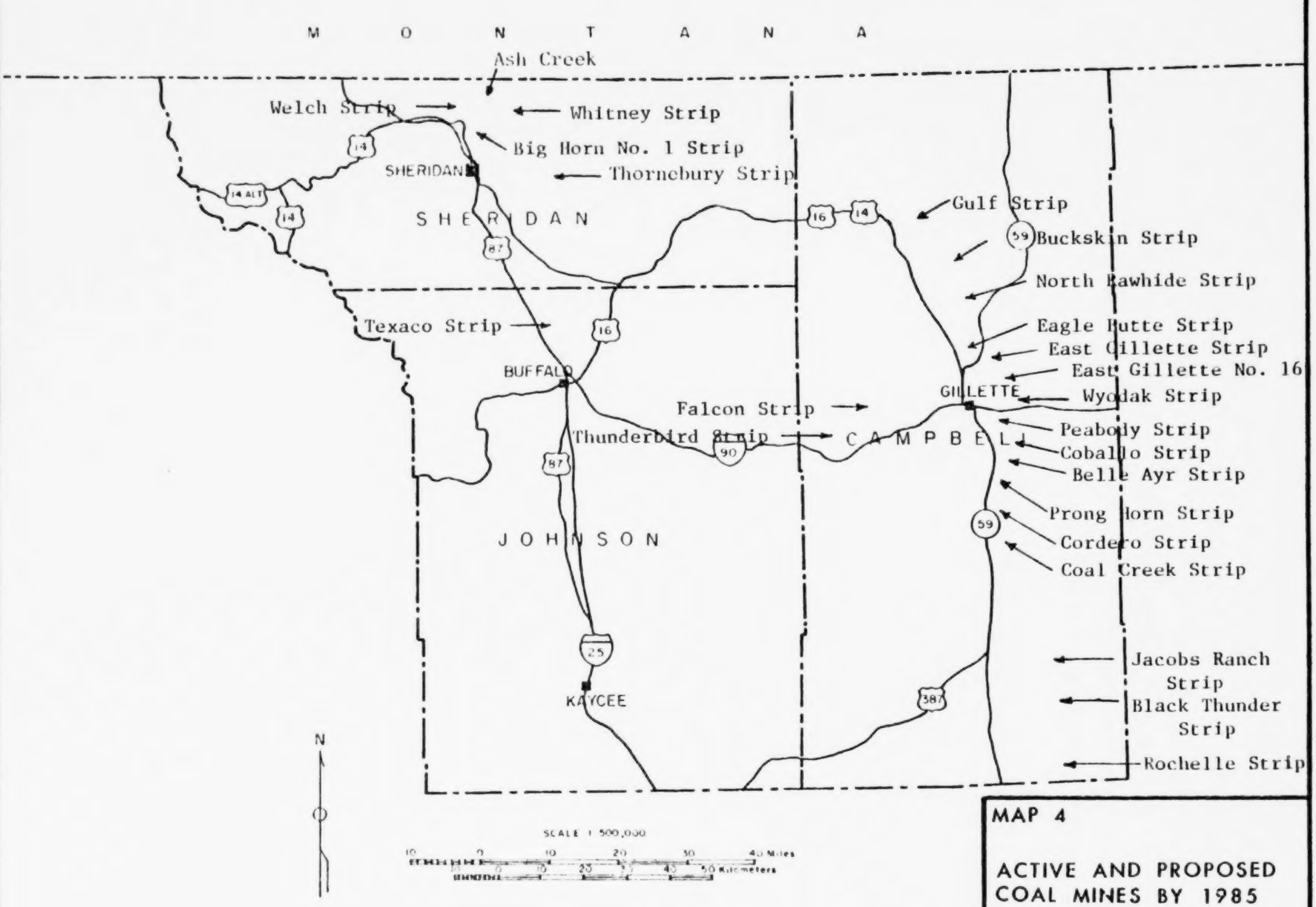
10 0 10 20 30 40 50 Kilometers

MAP 3

MAJOR MINERAL DEPOSITS

DRAWN BY ZIMMERGRAPHICS DATE 6-16-77


M O N T A N A
Ash Creek
Welch Strip
Whitney Strip
Big Horn No. 1 Strip
Thornebury Strip
SHERIDAN
S H E R I D A N
14 ALT
14
87
16
Texaco Strip
BUFFALO
Falcon Strip
Thunderbird Strip
90
C A M P B E L L
J O H N S O N
25
KAYCEE
387
59
GILLETTE
Gulf Strip
Buckskin Strip
North Rawhide Strip
Eagle Butte Strip
East Gillette Strip
East Gillette No. 16
Wyodak Strip
Peabody Strip
Coballo Strip
Belle Ayr Strip
Prong Horn Strip
Cordero Strip
Coal Creek Strip
Jacobs Ranch Strip
Black Thunder Strip
Rochelle Strip
N
SCALE 1:500,000
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10 0 10 20 30 40 50 Kilometers

MAP 4

ACTIVE AND PROPOSED COAL MINES BY 1985

DRAWN BY ZIMMERGRAPHICS | DATE 6-16-77

Source: WGS, 1977

Johnson County

Mining development in Johnson County most probably will be focused at the Lake DeSmet area north of Buffalo. In 1976, Texaco completed a major drainage and water storage project near the lake. Recent announcements from Texaco indicate that they intend to construct a coal gasification plant on their property. Other coal mining development may occur approximately 30 miles east of Buffalo near Barber Creek east of Johnson County.

As related to other mineral production, there could be uranium operations occurring in the Kaycee area and oil and gas production continuing in the southeast part of Johnson County. It appears that the major mining/energy production area will be near Lake DeSmet in the Buffalo area.

Sheridan County

As indicated on Map 4 mining development in Sheridan County will occur north of Sheridan near the Montana-Wyoming state line. Current development includes mining operations in the Bighorn strip mine north of Sheridan. Strip mining in this area is estimated to increase over the future years, with the result of increased employment activity from these mines which will certainly impact the cities of Sheridan and towns of Ranchester and Dayton. Map 4 also indicates the location of coal mines anticipated to be active by 1985 in Sheridan County.

Power and Synthetic Fuel Development and Other Industrial Development

Campbell County

In the near future a coal-fired electric generation plant will be in operation five miles east of Gillette. An electric generating plant located near a mine mouth or a coal gasification or liquification plant located in a mining area could increase the attractiveness of mining additional coal in Campbell County.

At the present time many industrial activities occur in the Gillette urbanized area. A number of these industries have supported the oil production industry in the past and will continue to support these and the other extraction industries in the future. From existing industrial land use patterns and transportation networks, it appears that industrial activities should occur south of Interstate 90 in the vicinity of State Highway 59. Future industrial areas, due to transportation and rail access, should probably be located at the west and east edges of the Gillette urbanized area. It is more difficult to serve industrial areas in the north Gillette area due to the fact that drainage north of the Gillette urban area flows in the opposite direction of the natural gravity flow of the sewage collection system and treatment plant. Individual treatment plants or lift stations would be required if a substantial amount of development occurs north of the urbanizing area of Gillette.

As indicated above, there will be a considerable amount of industrial activity supporting energy extraction industries. With this impetus for new industrial growth, there also will be the need for additional warehousing space, or what might be referred to as light industrial types of activities.

Johnson County

As indicated in a previous section, it appears that Texaco may develop a synthetic coal operations process near Lake DeSmet. Additional oil and gas discoveries in southeast Johnson County may stimulate continued drilling and production activity in this area. There may be development of a small uranium operation in the Kaycee area, as well as a uranium leaching process in the same area. Another mining operation which is considered an industrial land use is the continuation of the mining of bentonite. Johnson County ranks fourth in bentonite production in the state of Wyoming. Also sand, gravel and aggregate production apparently will continue to increase in the County. The County contains high-calcium limestone resources which may be marketable in the future.

Other industrial activities should be located in industrial parks as much as possible in the Buffalo and Kaycee areas and served by central sewage facilities if possible.

Sheridan County

Based on present information, the Pacific Power and Light Company is considering the construction of a large coal-fired power plant in Sheridan County. If a coal gasification plant is developed in the Lake DeSmet area or the south part of Sheridan County, Sheridan itself will be impacted by development of those facilities.

Major industrial development in the County other than present mining operations are concentrated in the Sheridan area. Industrial land uses have devloped contiguous to the Burlington Northern railroad tracks, near the central business district, and approximately one mile southeast of the central business district. However, the amount of industrial activity in the City is less than in other cities of that population range.

The proposed community development plan for the City of Sheridan shows expansion of industrial activities in the northeast quadrant of the City contiguous to existing industrial development, and to the southeast part of the urbanizing area. Both of these larger areas are contiguous to the Interstate highway. The plan also delineates the continuation of industrial activities east of the Burlington Northern railroad tracks, near the core area of the city, and continuing northward to the north edge of the anticipated urban area boundary of the city. It is recommended that major industrial activities locate in those areas which can be readily served by central water and sewer facilities as well as adequate public improvements of all types.

There is very little or no industrial development in the Town of Ranchester at the present time. The Comprehensive Plan developed for Ranchester indicates an industrial growth area south of U.S. Highway 14 near the present developed area of the City.

There is very little industrial activity in Clearmont at the present time. This activity is located between Highway 14-16 and the railroad tracks near Clear Creek Avenue. The proposed Comprehensive Plan indicates an industrial growth area to the southwest edge of the city between the rail trackage and U.S. 14-16 .

The Town of Dayton does not contain industrial land within its corporate limits; however, approximately three acres of industrial land use is located at the fringe area of the community. The Comprehensive Plan Map delineates future industrial development east of Broadway and north 4th Avenue and a tract west of the present developed area south on County Road north of U.S. 14.

The unincorporated area of Big Horn does not contain industrial activities at the present time. The plan for this unincorporated area does not anticipate future industrial uses.

The unincorporated area of Story contains very small amounts of industrial land and its corresponding Comprehensive Plan for growth does not indicate future uses of an industrial nature in that community.

Forested Lands Activities

Land Ownership and Management

Forested lands management in the three counties is the responsibility of the United States Forest Service (USFS), the Bureau of Land Management (BLM) and the Wyoming State Forestry Division. United States Forest Service Unit Plans and Management Framework Plans (MFP) define each agency's goals and efforts for a specified period of time in the future.

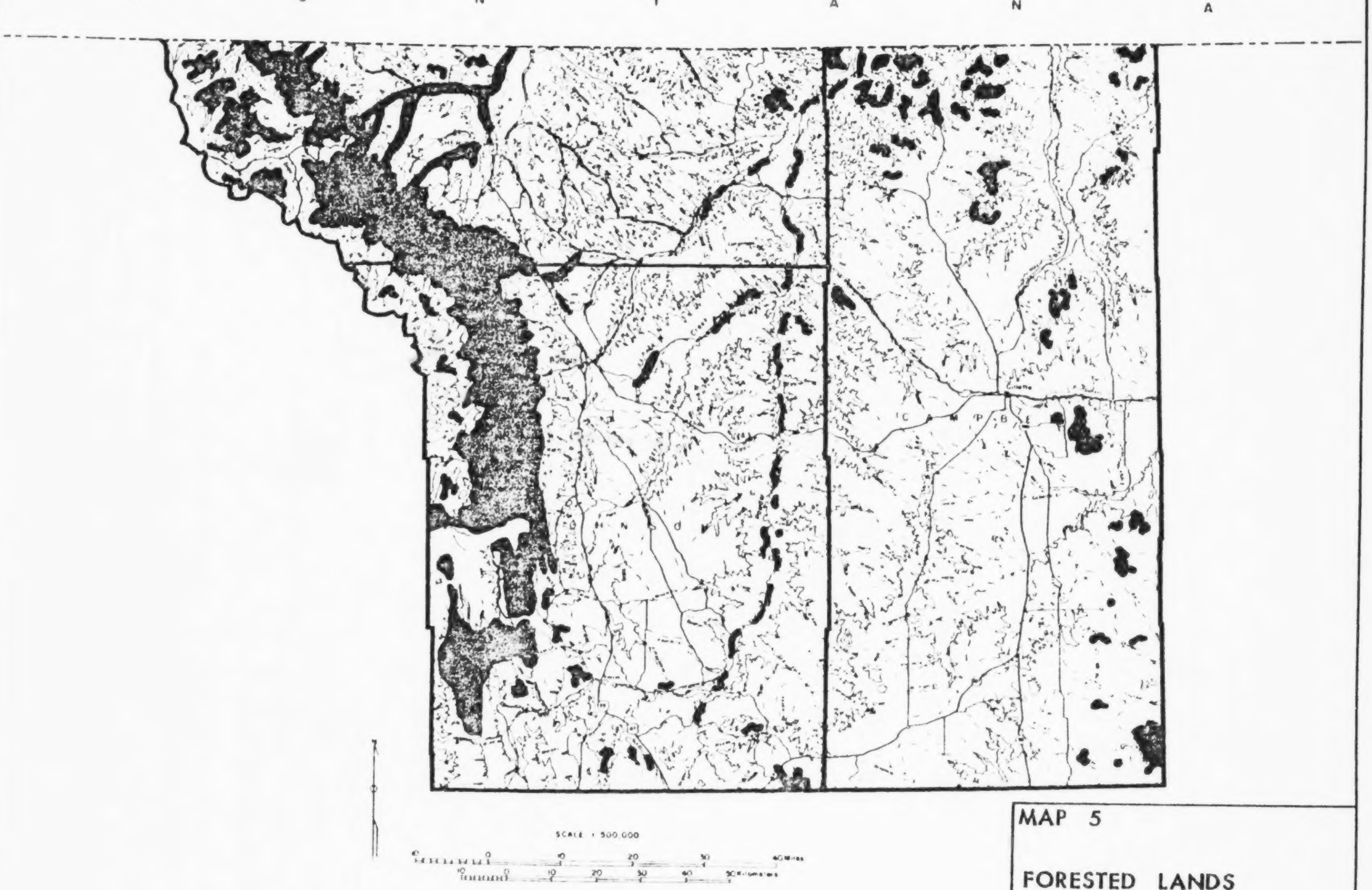
Forested land is primarily located along the western border of Johnson and Sheridan Counties, but additional acreages are dispersed elsewhere. Map 5 indicates the approximate location of all the forested lands in the three counties.

The three-county area supports a variety of livelihoods such as ranching, coal mining, petroleum recovery, farming, timber harvesting, minor manufacturing, and supportive businesses for economic vitality. Forested lands are affected by all of these activities.

Land development on forested land is managed by private enterprise, local governments, the State, the U.S. Forest Service and the Bureau of Land Management. Table 4 shows the administrative breakdown by acreage in the three-county area.

Forested Lands Administration

The bulk of the forested lands in the three-county study area is located in Johnson and Sheridan Counties. Several small areas in Campbell County are forested and provide excellent wildlife habitat and range supplement.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SCALE 1:500,000
0 10 20 30 40 Miles
0 10 20 30 40 50 Kilometers

MAP 5

FORESTED LANDS

Prepared for WRRI
by [illegible] GRAPHIC ARTS

DATE March 1977

TABLE 4

Approximate Forested Land
PRAPO Planning Area

County	Total Acres	Forest Service	BLM	State-Local	Private
Campbell	3,043,840	158,484[1]	14,490	4,028	31,610
Johnson	2,674,560	327,312	31,425	17,862	42,899
Sheridan	1,620,480	395,536	1,800	2,217	47,392

---

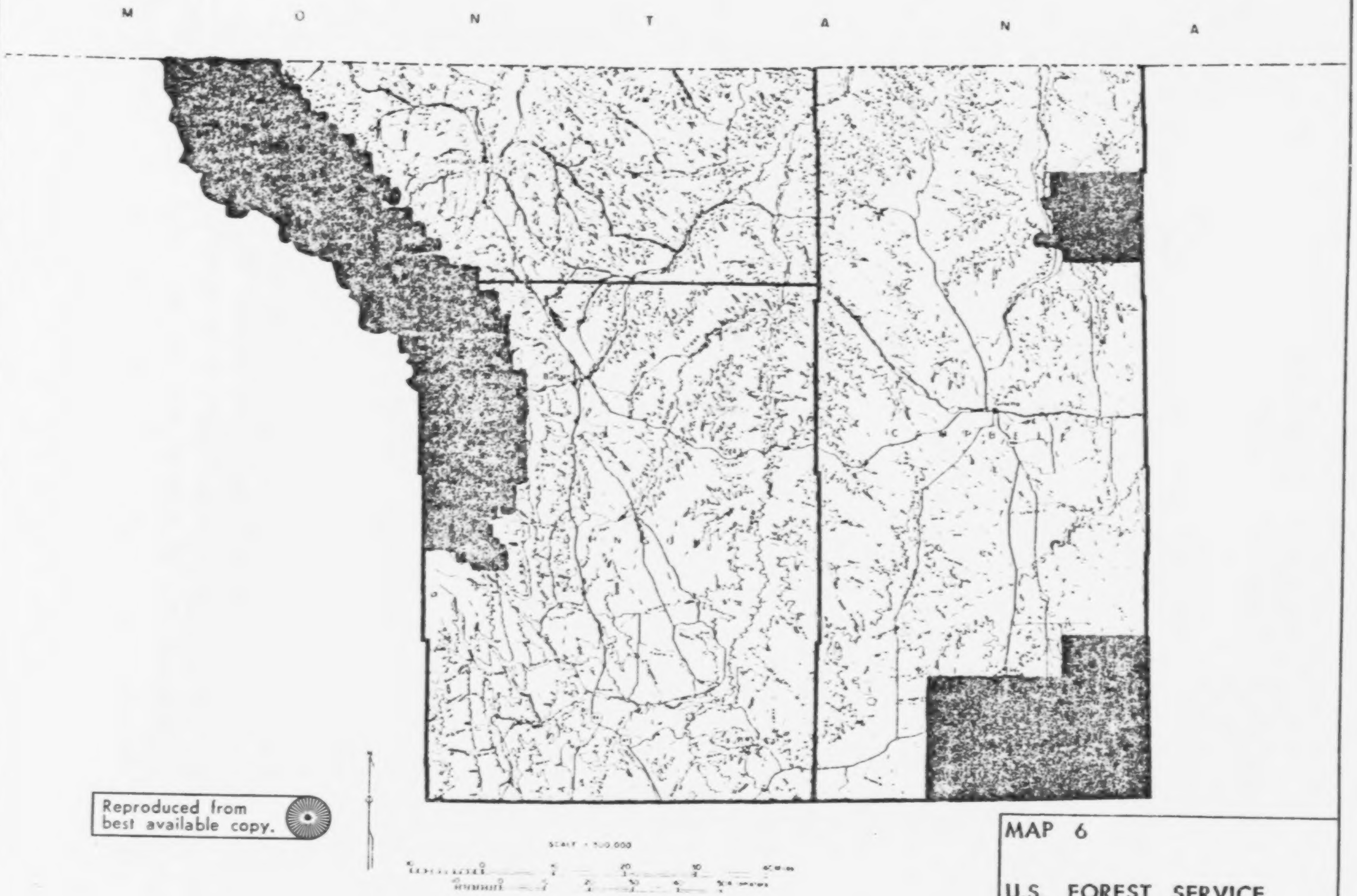
[1] Thunder Basin National Grasslands administered by USDA-Forest Service.

Source: Water Quality Management Considerations, Forested Lands Areas, Northeastern Wyoming, Water Resources Research Institute, p. 4.

Most commercially developed timber stands are located on federal land administered by the U.S. Forest Service within the boundaries of the Bighorn National Forest and on non-federal forest lands. Map 6 shows the Bighorn National Forest in Johnson and Sheridan Counties and the Thunder Basin National Grasslands of Campbell County, which is also administered by the U.S. Forest Service.

The Bighorn National Forest contains 1,107,342 acres of which 688,283 acres (68%) are comprised of actual forested land. Approximately 542,052 acres (48%) are suitable for timber management. This total includes the amount of National Forest in the three-county area. The water resources within the Bighorn National Forest cover approximately 53,840 acres or 5 percent of the total. The U.S. Forest Service administers the Bighorn National Forest through five district offices shown in Table 5.

District rangers and management specialists in each district carry out management programs which are coordinated by the Forest Supervisor's office in Sheridan. Five and ten-year plans are developed by considering specialist evaluations based on present and future needs, suitability of resources, intensity of the particular usage or activity and social-environmental conflict factors.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MAP 6

U.S. FOREST SERVICE
LANDS

Prepared for [illegible]
by [illegible] GRAPHIC ARTS

DATE March 1977

TABLE 5

Bighorn Range Districts

District	Location
Tongue[1]	Northwestern Sheridan County
Buffalo[1]	Northwestern Johnson County
Paintrock	East-central Bighorn County
Tensleep	Southeastern Bighorn - northeastern Washakie County
Medicine Wheel	Northeastern Bighorn County

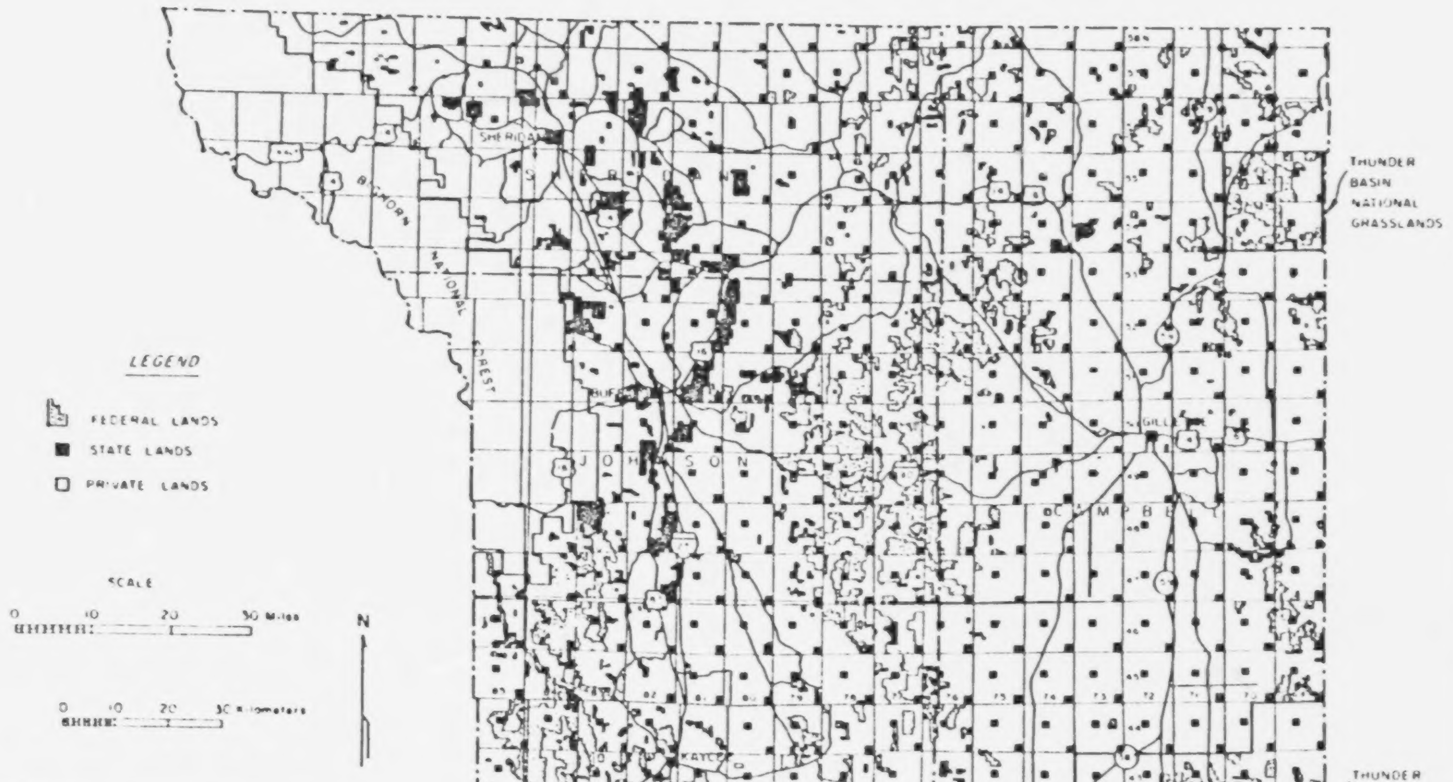
[1] Located within the three counties.

Source: Water Quality Management Considerations, Forested Lands Areas, Northeastern Wyoming, Water Resources Research Institute, p. 8.

The Bureau of Land Management administers approximately 50,000 acres of forested lands in Johnson, Sheridan and Campbell Counties. Substantial stands of ponderosa pine, spruce and lodgepole pine are available for harvest in the southwest part of Johnson County. At least six timber sales are under contract or proposed through 1982 in a five-year harvest plan within the BLM Buffalo Resource area. Future plans project harvests designed to rehabilitate mature timber stands and speed natural recovery toward higher use capacity. The BLM administration includes specialists to conduct multiple use programs in forestry, water resources, recreation, range management, mineral development, archaeology and land use planning. The Federal lands indicated on Map 7 consist of BLM-administered lands in the tri-county study area.

State, Local and Private Administration

Many acres of forested lands are state-owned and are administered through the State Forester's office in Cheyenne, and administrative districts located throughout the State. Map 7 shows the locations of surface land ownership and administration throughout the three-county area. Coordination between state, federal and private individuals has enabled the Wyoming State Forestery Division to negotiate cooperative agreements designating economically feasible land owners and resource managing agencies. Study plots and revegetative programs aid in regenerating areas of silviculture disturbance.


LEGEND
FEDERAL LANDS
STATE LANDS
PRIVATE LANDS
SCALE
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N
SHERIDAN
BIGHORN NATIONAL FOREST
JOHNSON
CAMPBELL
GILLETTE
BUFFALO
KAYCEE
THUNDER BASIN NATIONAL GRASSLANDS
THUNDER BASIN NATIONAL GRASSLANDS

MAP 7

SURFACE LAND OWNERSHIP

DRAWN BY ZIMMERGRAPHICS | DATE 6 [illegible] 77

The state is presently responsible for bringing state forested lands into full production, assisting private and county forest owners with management plans and coordinating with federal agencies on resource and conservation projects. The state is also responsible for fire management programs on non-federal forested and range lands and insect and disease control programs on non-federal forested lands.

Private, state and federal timber development and management programs must meet water quality standards developed by the Wyoming Department of Environmental Quality (DEQ) and maintenance classifications of the Wyoming Game and Fish Commission.

Forest Activities

The Water Resources Research Institute has identified six components of forest activities which have the greatest relationship to water pollution potential in the forested lands in the three-county area. These six activities include: 1) recreation; 2) silviculture; 3) livestock and wildlife management; 4) transportation development; 5) mineral development; and 6) fire management.

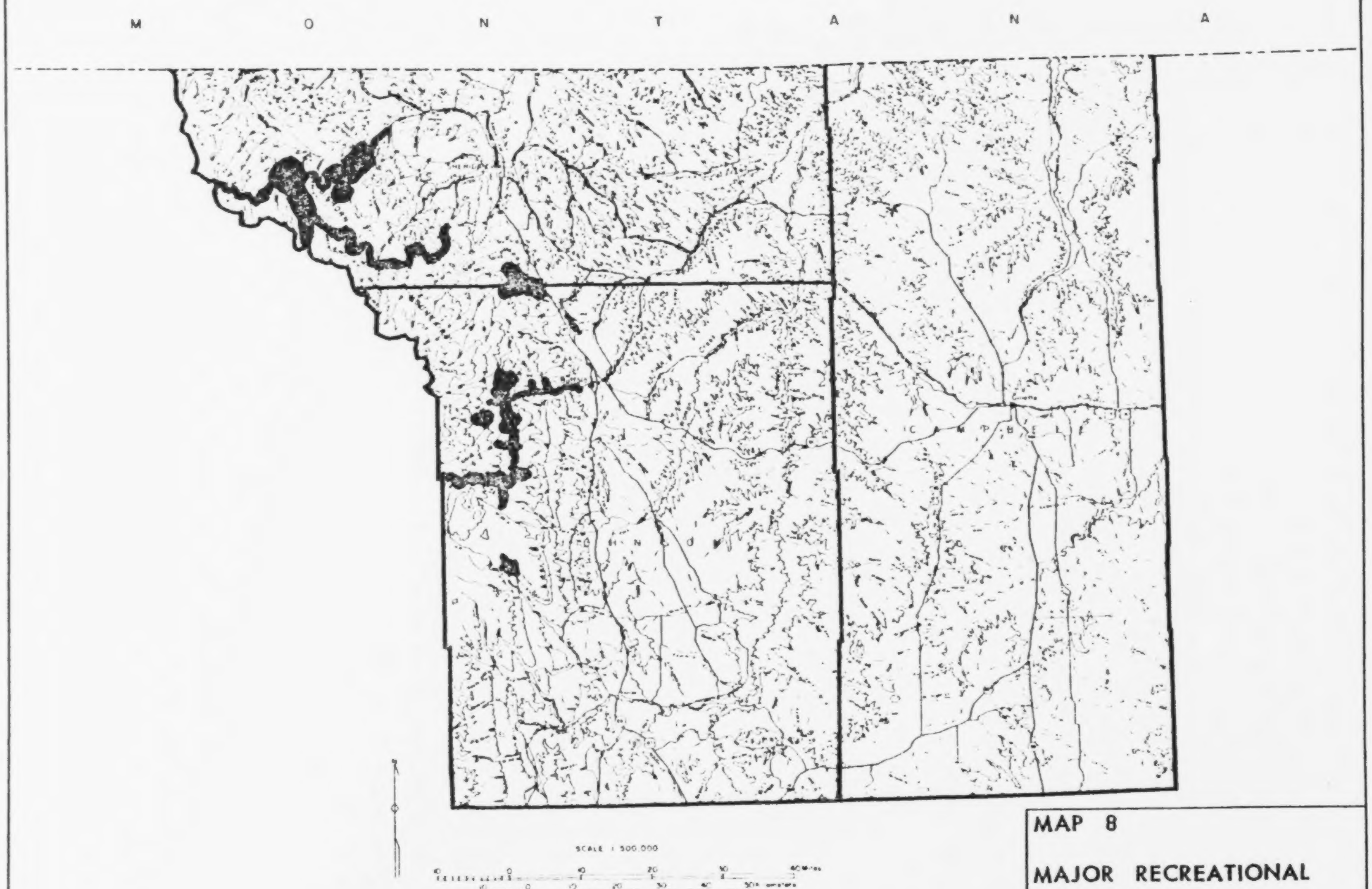
Recreation -

Nearly all accessible portions of the forested lands in Johnson, Sheridan, and Campbell Counties are utilized in varying degrees for recreational activities such as camping, picnicking, hunting, fishing, hiking, and recreational vehicle driving.

With increased population growth in the three-county study area, additional accommodations for recreationists can be projected along with increased wilderness activities and hunting and fishing activities. The major recreational areas are shown on Map 8 .

Silviculture -

"Silviculture" is defined by the Environmental Protection Agency to include all forest and management activities. The major timber harvest areas within the three-county area are managed by the U.S. Forest Service. These areas are shown on Map 9 . Other areas also however, offer the potential for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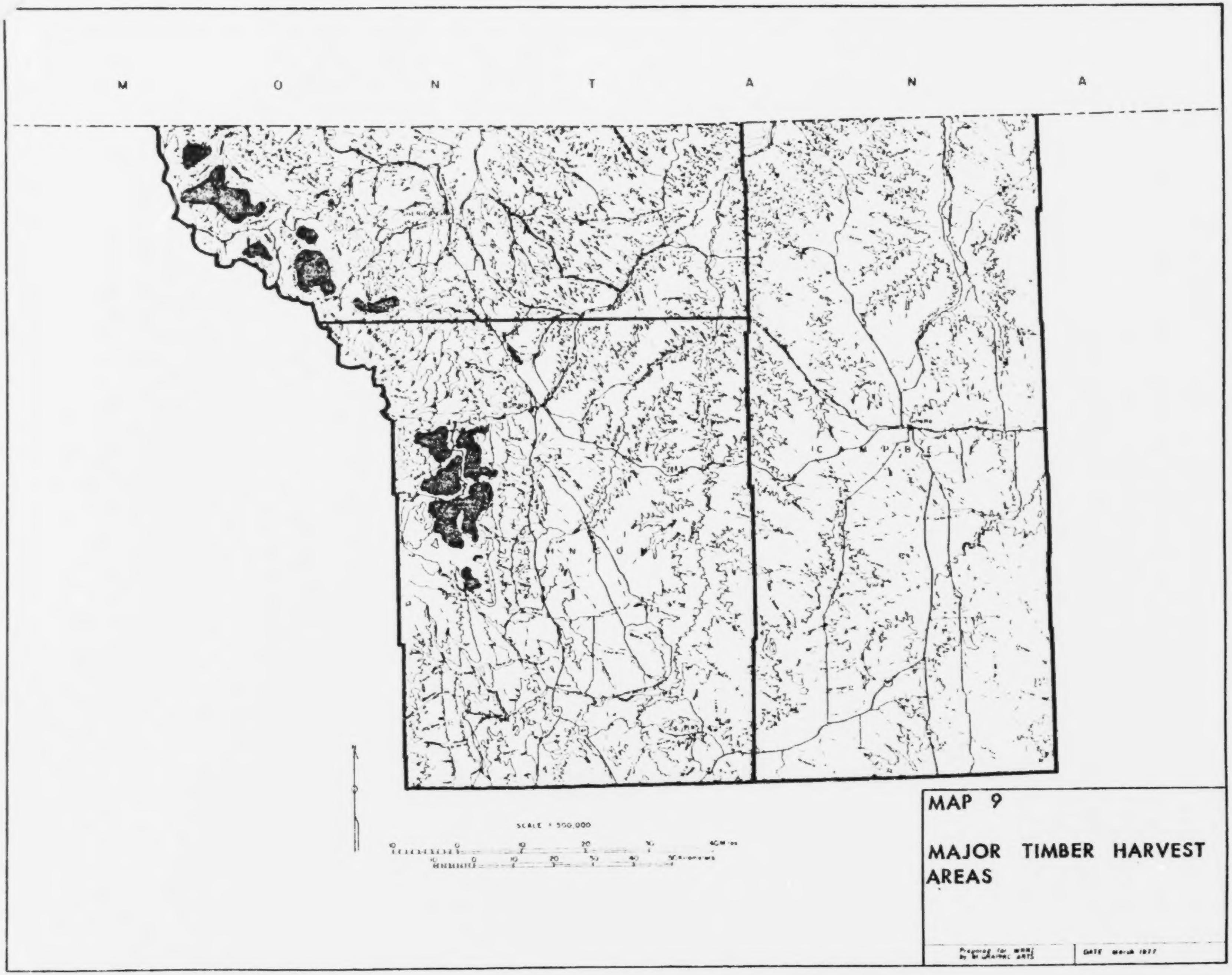
MAP 8

MAJOR RECREATIONAL AREAS

Prepared for WRRI
by SI GRAPHIC ARTS

DATE March 1977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MAP 9

MAJOR TIMBER HARVEST AREAS

Prepared for WRRI by Graphic Arts

DATE March 1977

economically sound timber harvesting. The Bureau of Land Management is initiating large-scale timber harvest programs in the southern Bighorn Range. The State has been conducting sustained yield timber harvesting in the Southern Bighorn Mountains for the past 20 years. The U.S. Forest Service has classified the Bighorn National Forest by land use areas for timber management. Approximately 68 percent of the land mass is suitable for timber harvest, while only 21 percent is ideally feasible for immediate development. Federal agencies have adopted ten-year plans projecting harvest forecasts, areas to be developed, reforestation projects, and road system completions, utilizing forest inventory surveys and various specialists' evaluations.

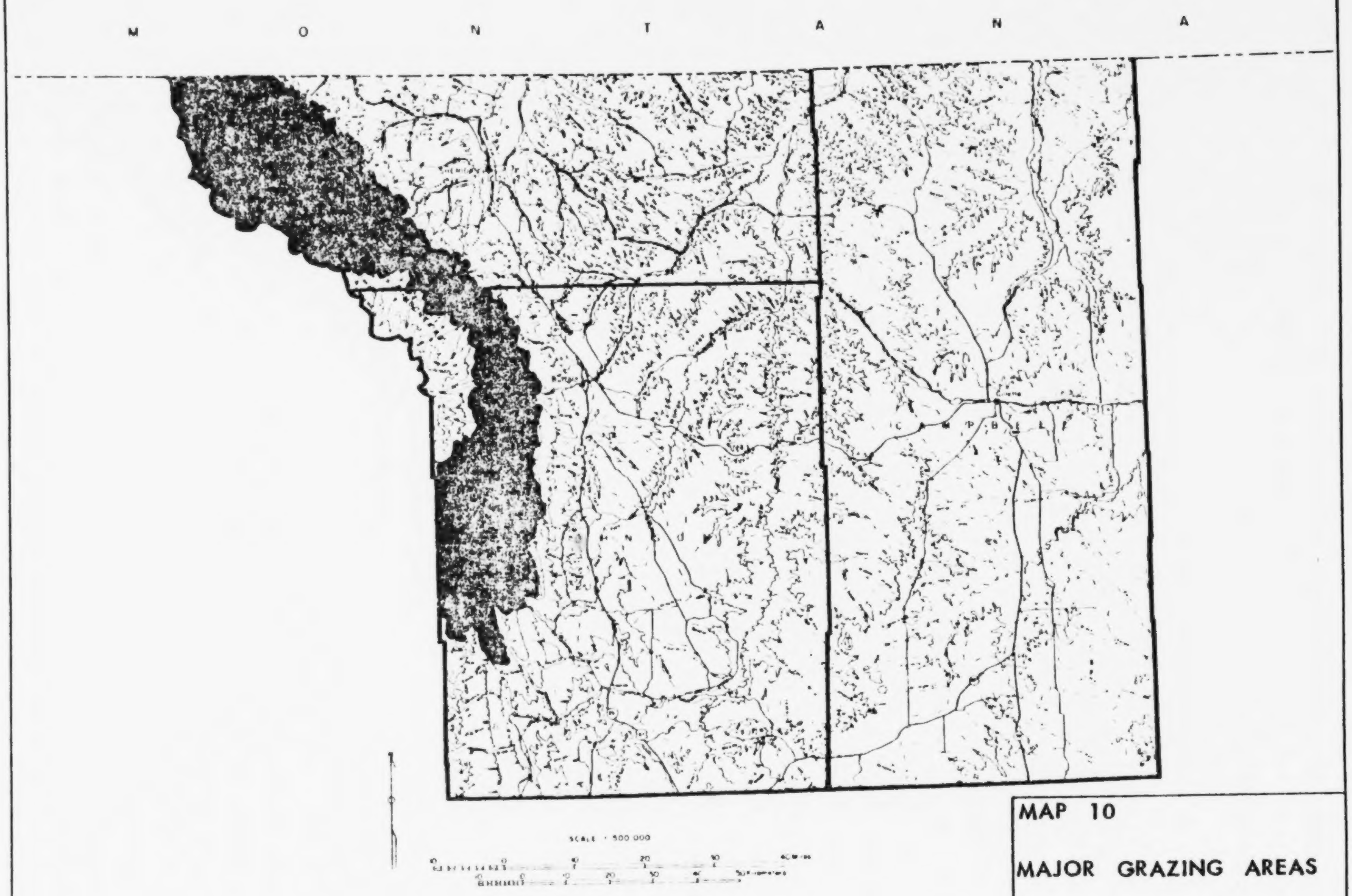
Livestock and Wildlife Management -

The forested lands in the three-county area provide summer range for cattle and sheep. Based on information from the U.S. Forest Service in 1975, at least 194 livestock grazing permits were issued to accommodate approximately 32,000 cattle and 52,000 sheep. Major grazing areas on federal forested lands are shown on Map 10 .

Specialists from state and federal agencies continually analyze the impact of interactions between livestock, wildlife, and habitat. The State of Wyoming has initiated a range of development programs particularly in southwestern Johnson County to include range evaluation, sagebrush control, herbicide and pesticide application, and private leasing of land to produce sustained yield from the range. Competition for range and habitat among deer, moose, elk, bighorn sheep, cattle, and domestic sheep presents problems related to migration, foliage distribution and grazing.

Transportation Development -

The major highways crossing the Bighorn Range include U.S. Highways 14, 14 Alternate, and 16. Access roads connect these major highways to provide access to lumber camps, timber sale areas, summer home groups, wilderness areas, camping sites, livestock camps, resorts, construction sites, fire lookouts, ski areas, and communication installations. Most unimproved roads in the Bighorn Range were originally constructed for livestock, recreational, and logging purposes, but presently are being utilized seasonally by camping parties, hunters,and livestock.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Miles
Kilometers

MAP 10

MAJOR GRAZING AREAS

Prepared for [illegible]
by [illegible] Graphic Arts

DATE March 1977

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Public utility routes exist across portions of the forested lands in the three-county area and petroleum pipelines are located along the flanks of the Bighorns and throughout Campbell County.

Mineral Development -

Full scale mineral development on forested lands in the three-county area has not taken place at the present time due to profitable deposits located in other areas with easier access. Approximate locations of active and non-active mineral development sites near forested regions are shown on Map 11 .

Favorable deposits of industrial material such as bentonite, gypsum, and high calcium limestone are located along the eastern flanks of the Bighorn Range and throughout southwest Johnson County. Mining operations are occurring in isolated sites and proposals for mining along the flanks of the Bighorn are being considered by private construction and industrial groups.

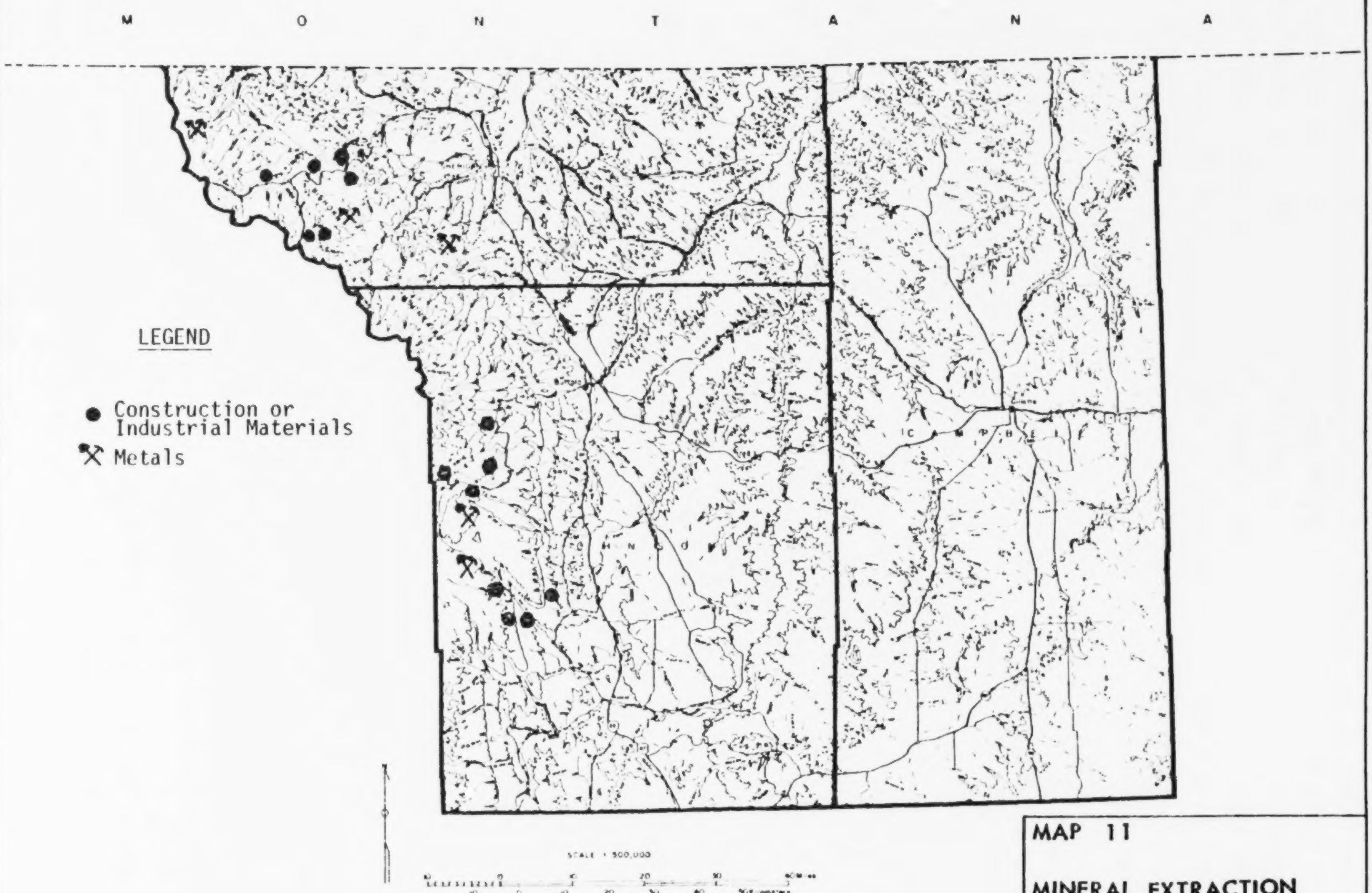
Bentonite and gypsum pit mining operations are occurring near small pits contiguous to the southern face of the Bighorn Range.

Construction materials are readily available in most areas of the forested lands of the Bighorn Range. Roads and maintenance of roads utilize most of the materials in the form of gravel, base materials and sands. Sand and gravel sources are available along the flanks of the Bighorns. Crushable aggregates are widely distributed in the Bighorn Mountains. Mineral deposits of gold, uranium, copper, manganese, and rare earth metals are found in precambrian granite and cambrian sandstones. Explorations for petroleum, coal and uranium have not indicated commercially developable deposits in the forested areas.

Future development of various mineral deposits could be economically feasible especially for construction and industrial materials. Nearly all of these deposits are located on the flanks of the Bighorn Mountains.

Fire Management -

Forest fires and activity can potentially be very destructive in forested areas. Fire fighting is proposed for all fires on federal lands which may


M O N T A N A
LEGEND
● Construction or Industrial Materials
⚒ Metals
SCALE 1:500,000
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10 0 10 20 30 40 50 Kilometers

MAP 11

MINERAL EXTRACTION AREAS

Prepared for [illegible]
by [illegible]

DATE March 1977

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endanger timber stands and property on the Bighorn Range. The Bureau of Land Management exercises its discretion concerning range fires. As an example, if no potential for loss of life or property is present the fire may be allowed to burn itself out. The Wyoming State Forestry Division encourages suppression of all fires burning on or threatening all State and private lands. Forest fires have historically played an important role in natural regeneration maintenance of preferred three species. Consequently, prescribed fire in specific areas may be necessary and feasible.

Controlled burning of slash piles resulting from timber harvests is undertaken generally after a snow cover has accumulated in the fall and winter. The majority of forest fires occur in late summer or early fall in the three-county area when dryness and increased usage potentially increase fire hazards. Table 6 presents a general percentage breakdown of frequent causes of wildfire.

TABLE 6

Causes of Wildfire

Cause	Percentage of Total
Lightning	35
Incendiary	21
Debris Burning	16
Campfires	8
Miscellaneous	7
Smoking	6
Equipment Use	6
Railroads	0.5
Children	0.5
Total:	100.0

Note: Does not correctly apply to State and private lands where lightning, debris burning, and railroads are the three leading fire causes.

Source: Water Quality Management Considerations, Forested Lands Areas, Northeastern Wyoming, Water Resources Research Institute, p.54.

In summary, future forest activities may steadily increase to meet the growing social and economic needs of the population of the three counties and surrounding counties. Specifically, recreational areas will be more greatly impacted from increased usage. The forested lands are suitable for development of recreational facilities, grazing areas, lumber products, minerals and water resources. The variety of natural resources and the usage of this potential area encourages preservation of the region. The natural resources in the three-county area are great and if properly managed, can provide desirable social, economic and environmental benefits in the future.

Agricultural Activity

Introduction

Historically, agricultural activity has been the major key economic support in the three counties. Although in the future there will be an influx of population to work in the energy extraction/production areas, agricultural activities will continue to provide strong economic support for the three counties. It is the citizens' goals within the three counties to maintain their agricultural resources and lands as much as possible.

Agricultural Land in Campbell County

Agriculture in the economy of Campbell County has changed from the principal economic support to a stable component of a diversified economy. Although coal, petroleum, and natural gas employment has increased, the role of agriculture as a component of the economic base remains strong.

The number of farms and ranches located in Campbell County is indicative of the continuing dominance of agriculture. The overall trend in Campbell County agriculture is toward large operations. Eighty-five percent of all agricultural operations in Campbell County were larger than 260 acres and 60 percent were larger than 2,000 acres in 1969. These percentages are considerably above statewide averages for that year with the State recording that only 30 percent of all agriculture operations were larger than 2,000 acres. Livestock and crop production are the two predominant types of agricultural operations existing in Campbell County.

In 1969, it was reported 3,069,561 acres of land were in farms and ranches in Campbell County, with the average size of operation amounting to 6,408 acres. Of the three counties, Campbell County contains the greatest amount of cropland farming, with only a negligible amount in irrigated farming. Dry cropland farming is located throughout the county with major amounts near Gillette, in northwest portions of the County and in the south portion of the County. The remaining lands consist of rangeland or similar types.

In summary, from all available indicators, agriculture will continue to be a dominant force in the Campbell County economy. Although coal mining will intrude upon potential agricultural land, available information suggests that useable land resources in the County are extensive enough to support the continuation of a healthy agricultural sector.

Agricultural Land in Johnson County

The agricultural economy in Johnson County is extremely stable and will continue to be a stable economic force in the County in the years ahead. The average size of farms in Johnson County amounted to 7,803 acres in 1969, which amounts to 3,780 acres larger than the average size of farms in Wyoming as a whole.

Total agricultural lands in the county amounted to 1,737,941 acres with cropland amounting to 50,993 acres. There were 1,624,339 acres in rangelands, 60,761 acres in forest lands and 1,848 acres in other classifications. Of the total acreage in cropland production, 45,133 acres consisted of irrigated cropland. This indicates that there are only 5,860 acres of non-irrigated cropland in the county. The irrigated croplands are located along the stream valleys east of the Big Horn Mountains. The dryland crop farming is located basically north of Kaycee in a north-south direction extending to the Buffalo area. The remaining portions of the county outside of forested areas consist of rangeland.

Agricultural lands will be affected to a lesser degree by coal mining in Johnson County than the other two counties due to the fact that the county does not contain any vast amount of strippable coal reserves which are located in the other two counties.

Agricultural Lands in Sheridan County

Sheridan County also enjoys the advantages of a strong agricultural base in its healthy economy. Other strong supports are tourism, education, and the mining extraction/production industry.

Agriculture is a predominant use of land in Sheridan County. Total land in farms and ranches in the County amounted to 1,508,873 acres in 1969 which amounted to 93.1 percent of the total land in the County.

The irrigated croplands are located in the stream valleys east of the Bighorn Mountain Range. Of the harvested cropland amounting to 67,245 acres, 60,801 acres were under irrigation. The east portion of the county basically consists of rangeland with some dry land crop farming in some locations. The goals of the citizens of Sheridan County are to preserve the agricultural base of the economy, to discourage prime irrigated agricultural lands from becoming developed and to encourage future urban growth areas in dry land areas.

Although the economic base of Sheridan County may be somewhat more diversified than Campbell or Johnson Counties, agricultural activities will continue to be a strong economic support in the county, if agricultural lands are protected from development for other purposes.

WATER QUALITY ASSESSMENT AND NEEDS

Urban Land Use - Water Quality Relationships

Water quality management planning calls for an evaluation of the environmental impact of alternative and physical land use controls on water quality management. Areal sources as well as discharges from treatment plants need to be considered. Facility planning under Section 201 and Section 208 of the Public Law 92-500 has been concerned primarily with treatment plants and major interceptors.

Land and water resources are interrelated. Therefore, water quality management requires land use planning in conjunction with transportation planning, recreation planning, industrial development planning, preservation and conservation planning, public facility planning, as well as water resources and water quality planning.

Local land use decisions take place in an arena where certain groups show strong concern for the environmental impact and for the potential overutilization of an existing infrastructure. By arriving at an impact of areawide development as well as local development given for existing pollution control standards, water quality professionals can determine if these impacts are undesirable relating to existing standards. Policies can then be designed to alleviate any undesirable impacts which may be revealed.

Studies and research have attempted to provide a balanced characterization of the effects of urban land on instream conditions. In order to define the water quality aspects of particular non-point sources, there must be an analysis of existing water quality data, and the collection of additional water quality data through well structured sampling programs and analysis techniques. In the report "Planning Methodologies for Analysis of Land Use/Water Quality Relationships" prepared by the Environmental Protection Agency, it is suggested that the proposed approaches be undertaken in attempting to describe the water quality aspects of non-point sources: "1) Determine what kinds of non-point problems exist, their extent and severity; 2) Rank non-point problems based upon water quality impairment and probability control; 3) Recommend general 'Best Management Practices' for selected sources; 4) Present site-specific recommendations on significant non-point sources; 5) Develop a long-term program for further study of unresolved non-point problems along with a specific monitoring problem to aid future analysis and help gauge pollution control progress."

This approach focuses on the reaction of the receiving water to non-point loads and does not necessarily concentrate on analyzing loads delivered to the receiving waters. If a structured water quality monitoring and analysis program indicates no significant water quality problems due to non-point sources, it does not appear appropriate to commit resources in developing estimates of pollution from land uses and watersheds.

The following discussion of land use/water quality relationships will focus on urban land use/water quality relationships, basically related to non-point sources.

Water pollution in the three counties may originate from discrete, localized operations which generate point pollutional discharges easily isolated and amenable to treatment, or from sources which can be considered non-point. Table 7 summarizes some of the information which is available on urban areal and non-point source emission rates for BOD, CO, NO_3-N, Total N, Total P, and sediment. The data are appropriate for order of magnitude analysis, but cannot be used for predicting pollution levels. A detailed analysis must be made of the soils, topography, climate and other such features of a site to derive emission factors for any given locality.

Campbell County[1]

When evaluating existing or potential water pollution problems, it must be

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[1] Land Use-Water Quality Relationships, Campbell County, Wyoming, City/County Department of Planning and Development, p. 1, 2, 3, 5, 7, and 10.

TABLE 7

Non-Point Source and Urban Stormwater Emission Rates (lb/acre/yr)

	COD (lb/A/Yr)	BOD (lb/A/Yr)	Total NO_3-N (lb/A/Yr)	Total N (lb/A/Yr)	Total P (lb/A/Yr)	Sediment (lb/A/Yr)
Forest	--	--	.62-7.8	2.7-11.6	.027-.27	@75
Range	--	--	.62	--	.07	@750
Active Cropland	--	--	--	.09-11.6	.05-2.6	@15,000
Irrigation in Western U.S.						
a. Surface Drainage	--	--	--	2.7-24	.89-3.92	--
b. Sub-surface Drainage	--	--	74.	37.4-166	2.7-8.9	--
Cropland Tile Drainage	--	--	--	.27-11.6	.009-.26	--
Urban	196-276	27-45	--	6.2-8	.98-5.8	@16,000
3 DU/Acre Sewage Treated*	240.	95.9	63.4	63.4	12.8	31.9
3 DU/Acre Untreated	1598.1	639.3	0.0	127.8	31.9	213.1
Construction	--	--	--	--	--	3,000-375,000

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* Standard Secondary Treatment, 60% P Removal, 85% BOD Removal, 50% Nitrification. DU defined as dwelling unit.

@ is the symbol being used to mean "approximately".

Source: Land Use-Water Quality Relationships, Environmental Protection Agency, p. 5-19
Land Use-Water Quality Relationships, Campbell County, Wyoming, City-County Department of Planning and Development, p. 2.

recognized that there are few perennial streams in Campbell County. Thus, water pollution originating from urban sources may be serious only during flood stages of the ephemeral Donkey Creek/Stonepile Creek drainage system. Unless the sediment (or other pollutant) is transported to perennial streams or lakes, the national goal of habitable water for wildlife and water suitable for recreational purposes by 1983 is unaffected. Quantities of sediments deposited in the Belle Fourche River and Keyhole Reservoir could be increased by urban development in the Gillette area. With ninety percent (90%) of the County's residential growth forecasted to be in this area, these perennial waterways are the only ones anticipated at this time to be affected by urban development.

Urban Development -
Urban land use in Campbell County has occurred within the several categories in a variety of ways, and depending upon the type, location, physical factors, and quality of the development, has contributed to water pollution at varying levels and has originated from many practices. The following is an analysis of some of the more salient sources of water pollution in and near the City of Gillette.

Urban Runoff -
According to recent estimates, the population of Campbell County has increased approximately fifty-five percent since the 1970 U.S. Census. Many residential developments are not constructed in phases and consequently large areas are denuded of vegetation. They therefore contribute to water pollution, especially sedimentation, at a higher rate than would normally be expected.

It has been demonstrated that urban runoff produces about the same order of magnitude of pollutant as secondary effluent from separately treated sanitary sewage, with the exception that it is somewhat lower in total nitrogen and higher in sediment. Primarily, the increase in runoff in urban areas is a product of the creation of impervious surfaces, such as rooftops, streets, sidewalks, etc. The pollution is a function of the accumulation of pollutants on impervious surfaces, and the transport of pollutants from these areas by the runoff. In addition, increased runoff may cause an increase in the rate of water induced erosion.

The U.S. Weather Bureau has calculated quantities of rainfall which may be expected during storms of varying magnitude in the City of Gillette. The following is a list of rainfall intensities and the frequency in which the storm level may be expected to occur.

Storm Frequency	Precipitation Inches per Hour
2 years	0.7
5 years	1.1
10 years	1.2
25 years	1.4
50 years	1.6
100 years	2.0

An area near Gillette, mostly in grassland, may be expected to produce from ten to thirty percent of the rainfall accumulation as runoff. The downtown business areas may yield from seventy percent to as much as ninety-five percent.

With these considerations in mind, runoff yields have been determined for six (6) drainage areas in the Gillette area, and yields have been projected for each area for that time in the future when development has been completed. Additional information is provided in the report "Land Use-Water Quality Relationship" prepared by the Gillette/Campbell County Department of Planning and Development.

An increase in the amount of runoff produced in a given area does not necessarily indicate that there will be a corresponding or resulting increase in water pollution. It does, however, signify that the pollutant transport mechanism has developed an expanded load capacity. In an area such as Gillette where perennial streams are nonexistent, such an increase could be of considerable importance. Measures which could be directed at reducing the gross land area developed as impervious surfaces include mandatory park land dedication, encouraging maximum open space by utilizing the Planned Unit Development method of development, and reducing pavement widths required by street standards.

A limited urban runoff assessment was undertaken for Sheridan, Gillette and Buffalo during the indicated performance of the overall study. These findings are in Chapter III.

Unpaved Roads -
While pavement increases the amount of impervious surface in an area and results in an increase in runoff, the alternative of not paving street surfaces and thus allowing for a greater pervious surface area would likely cause an even greater increase in water pollution in the form of sediment. The majority of the unpaved streets or roads in the City and County have been surfaced with scoria (a clinker-like material) which has a tendency to separate after about one year's time with moderate traffic. At that time, much of the material is of small particle size and with traffic or wind, often becomes airborne in the form of dust. The dust may then accumulate on impervious surfaces or other areas where water can transport it to streams, thus producing sediment.

Where residential densities are low, streets are further separated from one another, traffic volumes are much lower, and sediment production is minimal. The majority of the land subdivisions without paved streets in Campbell County are of low density and pavement is not necessary. Subdivisions with a proposed density in excess of one unit per acre are now required to have their streets paved with a bituminous substance. There are, however, a few subdivisions which were approved prior to the adoption of this requirement. In the future, any subdivision which is approved without pavement will be of a low density and maintain relatively light traffic. At this time the one exception would consist of mobile home parks, where pavement is not required in unincorporated areas. Many of these parks must be considered temporary only, and pavement may not be necessary in short-term developments.

Floodplain Development -
Much of the City of Gillette has developed within the boundaries delineated on the "Flood Hazard Boundary Map for the City of Gillette, Wyoming", which was a quick, cursory study of the flood boundary prepared in order that the City might participate in the National Flood Insurance Program. As a participant, the City has adopted a restrictive ordinance which will not allow residential uses, dumping, filling, and sheltering of animals in the areas designated as "Floodplain Areas Having Special Flood Hazards."[1] Structures may not be

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[1] The "Floodplain areas having special flood hazards" are defined as that maximum area of the floodplain that, on the average, is likely to be flooded once every 100 years.

constructed unless the applicant for a building permit can show that the structure will not impede drainage and will not substantially reduce the floodwater storage capacity of the floodplain. Any structures that are allowed will be flood-proofed above the level of the one hundred year flood. None of the nonconforming uses of the floodway will be allowed to expand, but will be allowed to be repaired for flood-proofing.

The Subdivision Resolution of Campbell County requires a drainage report with the Subdivision Application, and the dedication of any necessary drainage easements. The land will be set aside for uses "which will not aggrevate the danger of flood hazard, will not endanger the general health, safety, or welfare of the community".

These positive steps taken by the City and County will ensure that floodplain development will be minimal, and flood-related pollution likewise minimized. The task is to decrease the flood potential in those areas where development has already taken place, maintain water quality where development has already taken place, maintain water quality by removing certain uses from the floodway, constructing a storm sewer system, and minimizing inflow and infiltration into the sanitary sewer system during storm periods.

Construction -

Removal of vegetation and excavating land for residential, highway, and other projects, has had an adverse affect on air quality in the windy Gillette area, and with deposition of some of the airborne particulates in stream channels or on impervious street surfaces, it could have an affect on water quality. The Uniform Building Code, adopted by and enforced in the City of Gillette, maintains provisions for minimizing erosion occurring from a completed grading project. In Campbell County, the major erosion problem is during construction phases, not so much after completion.

Quantitative data concerning the increased amount of sediments generated during construction phases of land development in Campbell County are lacking. A few published data on the relationship between construction activities and pollutant accumulation exist; however, their use for general application is highly questionable. Table 7 , which provided general non-point emission rates by land use type, indicates that construction can result in sediment production ranging from 3,000 to 375,000 pounds/acre/year. Although this is an extremely wide range, it shows that if areas are denuded of vegetation and soils are not properly anchored, severe erosion can occur.

Johnson County[1]

Urbanization -

Areas of dense urban concentration in Johnson County are limited to Buffalo, Kaycee, and to a lesser degree, Linch. A growth area of potential concern is northwest of Buffalo between French and Rock Creeks and consists of a number of subdivided tracts which average 5 acres in size. These tracts contain individual water and sewer systems. This situation may lead to many interrelated problems such as depletion and/or contamination of the groundwater source and the potential contamination of the existing free flowing streams.

A monitoring of stream quality is necessary to provide effective information to local officials who will prepare and revise future guidelines for control of growth in moderate or low density rural areas. If water quality is not being affected, then more stringent requirements or regulations will not be needed. On the other hand, if water quality is being adversely affected, then a mechanism is available to prevent the situation from further degradation.

Buffalo and Kaycee will continue to experience dense urban type growth in the forthcoming years. Urbanization brings with it a number of factors which can affect water quality as land use changes occur. Some of these factors will be only minor while others could be more serious and require extensive treatment or other considerations if water quality is to be maintained.

As land is converted to urban uses the amount of soil which can absorb moisture is reduced. This is due to the fact that the area will be covered with paving, sidewalks, buildings, and other types of developments. This in turn reduces groundwater supplies in the immediate area. However, neither Buffalo nor Kaycee rely on groundwater for municipal water. In contrast, runoff waters are increased and greater volumes of water reach streams which are usually used as the termination point for storm sewers or municipal runoff.

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[1] Relationships Between Variations in the Physical-Social Environment and its Capability to Assimilate Growth and Development, Johnson County, Buffalo-Johnson County Planning Office, p. 53-55.

Storm waters also pick up materials from various locations and in some cases will deposit them in either Clear Creek (Buffalo) or Powder River (Kaycee). The lack of an extensive storm sewer system in either town results in a slower transport of these materials into a live body of water. A greater concern, however, should be raised for any snow and ice removal chemicals that may reach Clear Creek or the Powder River. This is notably the situation due to the fact that storm drains are installed on the two heaviest travelled arterial streets in Buffalo. In Kaycee the problem is less severe as there are few direct runoff paths to the Creek.

Sand is used for traffic safety on ice and packed snow. Some of this material may also reach bodies of water. However, in Kaycee this amount of material is limited because of street locations, limited paved streets and the topography. In Buffalo the sand is swept and recovered for reuse whenever possible.

Other Factors -
The discussion concerning unpaved roads, stormwater floodplain problems as applicable, and construction in Campbell County apply in general terms to Johnson County and Sheridan County as pertaining to urban land use/water quality relationships.

Sheridan County[1]

To obtain an overview of land use/water quality relationships in Sheridan County, it is necessary to review the urban development patterns in the County. Nearly all of the urban development and the majority of all rural residential development has occurred in the stream valleys in the County. The valleys contain irrigated croplands and the principal location of all mining activities, as well as providing a major component of the County's wildlife habitat and fisheries. This indicates that the land use/water quality relationships are focused basically in the valleys of the County.

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[1] Land Use-Water Quality Relationships, Sheridan Area Planning Agency, pp. 1,6, 10, 11, 12, and 13.

The concentration of many residences mainly in the valleys poses the question of whether septic tanks and leach fields are adequate to accommodate the sewage disposal needs of the residents. The effluent of inadequately constructed septic tanks mixing with surface runoff may flow into nearby streams. The effluent can also percolate into improperly constructed water wells and contaminate sources of domestic water.

Urbanization, whether at urban densities, or lower rural densities, produces increased amounts of runoff and sedimentation. Typical subdivision construction is initiated by removal of vegetation and grading of the land to desired surfaces and contours. This practice causes problems if construction is delayed or if a large area of land is involved, resulting in possible large-scale erosion. Increase in sedimentation does not decrease after construction, but will continue due to the impervious nature of roofs, sidewalks, etc. Petrochemical levels in runoff are higher in urban areas than in rural areas. A higher concentration of automobiles is the main cause for an increase in runoff pollutants under cold weather conditions.

Identification of Existing Water Resources

Surface Water

The total area of the three counties is located in the Upper Missouri River Basin of Wyoming. Map 12 illustrates the location of the major streams of the area. Table 8 lists these rivers and presents general watershed characteristics for each.

Table 9 presents a review of the historical flow patterns at the major gauging stations in the planning area. To facilitate the water quality analyses, these rivers were divided into segments of varying lengths. These divisions were made to isolate the current or expected water use in each segment. Comparisons of the water quality for the period of record with various criteria or standards can determine the acceptability of the water for a specific proposed use.

TABLE 8

Watershed Areas and Elevations: PRAPO Planning Area

Watershed	Surface Area (square miles)	Elevations Maximum	Elevations Minimum
Powder River at Moorehead, Montana	8,088	10,555	3,334
Tongue River at Decker, Montana	1,477	9,581	3,430
Goose Creek at mouth	435	10,915	3,701
Clear Creek at mouth	1,110	12,281	3,506
Crazy Woman Creek at mouth	1,070	10,555	3,750
Prairie Dog Creek at USGS gage	358	4,400	3,450
Belle Fourche River	670	4,800	4,600
Cheyenne River	1,716	4,820	4,560

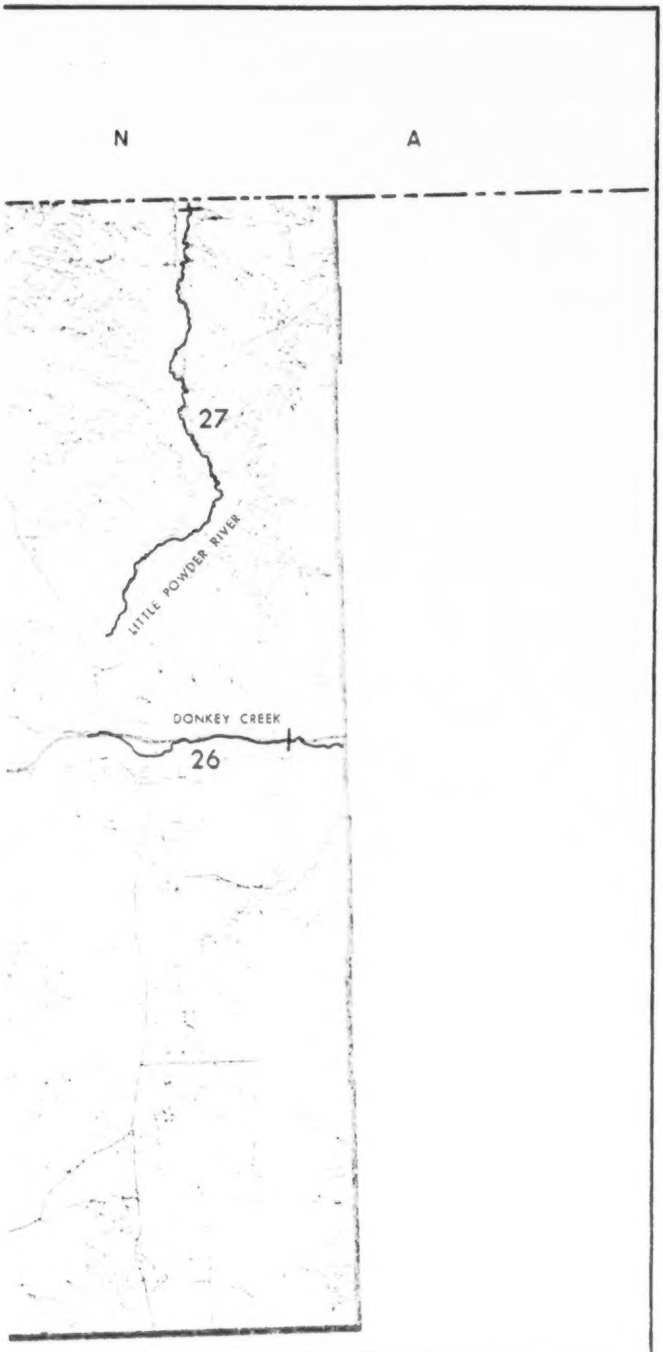
Source: Assessment Report and Recommendations, PRAPO Planning Area, WRRI, p. 8.

TABLE 9

Stage-Discharge Relationships: Major PRAPO Watersheds

Watercourse	Period of Record (years)	Discharge (cfs) Avg.	Discharge (cfs) Max.	Discharge (cfs) Min.	Maximum Gage Height (feet)
Powder River at Moorehead, Montana	44	458	23,000	0	12.8
Tongue River at Decker, Montana	15	514	7,480	3	10.9
Goose Creek in Sheridan	34	184	5,450	4.0	7.8
Clear Creek near Arvada	36	183	9,600	0	10.5
Prairie Dog Creek near Acme	5	45.6	738	6.6	6.0

Source: Assessment Report and Recommendations, PRAPO Planning Area, WRRI, p. 9.


N
A
27
LITTLE POWDER RIVER
DONKEY CREEK
26

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MAJOR STREAM SEGMENTS AND SYSTEMS

MAP 12

PREPARED BY: OBLINGER-SMITH CORPORATION

Prepared for WRRI
by UI GRAPHIC ARTS

DATE: March 1977

43.a

There are no perennial streams within the study area for either the Belle Fourche or Cheyenne River drainage basins. A series of ephemeral or intermittent draws carry seasonal runoff which has insignificant volume when compared to the other river systems in the region.

The most important hydrologic factor in the three-county area is the variation in water availability between the eastern and western portions of the study area. Sheridan and Johnson Counties receive surface runoff from the accumulated snowpack in the Big Horn Mountains. The streams are generally clear, cold and in the past, contained adequate water to satisfy most demands. Surface sources provide Sheridan and Buffalo with municipal water. Groundwater development is not as critical as it is in other parts of the study area or the state.

Surface waters in Campbell County are rare. Less than 0.01 percent of the total county area is comprised of water surface. Municipal as well as domestic demands are met by groundwaters. Surface waters where present usually result from the interception of water tables or the impoundment of seasonal runoff. These waters are usually more saline, maintain higher temperatures and provide less uses than do the surface resources in other parts of the study area.

A total of 158 water quality stations were used to evaluate the stream segments identified in Table 10. Map 12 shows a delineation of the stream segments and Map 13 illustrates the locations of each of these stations.

TABLE 10

Stream Segments: PRAPO Planning Area

River/Stream	Segment	Use(s)
Tongue	1. Source to Dayton	Drinking water/secondary contact/ recreation/agricultur/wildlife and livestock watering/fishery
	2. Dayton to Monarch	Drinking water/primary contact/ recreation/agriculture/wildlife and livestock watering/fishery
	3. Monarch to below Goose Creek	Body contact recreation/agriculture/wildlife and livestock watering/fishery

TABLE 10 Continued

River/Stream	Segment	Uses(s)
	4. Below Goose Creek to State Line	Body contact recreation/agriculture/wildlife and livestock watering/fishery
Youngs	5. Entire length	Agriculture/wildlife & livestock watering/fishery
Goose	6. Source to inlet	Drinking water/recreation/agriculture/wildlife & livestock watering/fishery
	7. Inlet to Sheridan	Recreation/agriculture/wildlife & livestock watering/fishery
	8. Through town to confluence to sewage outfall	Body contact recreation/ agriculture
	9. Sewage outfall to Plachek Pit	Recreation/agriculture/wildlife & livestock watering
	10. Plachek Pit to confluence	Recreation/fishery
Little Goose	11. Source to Big Horn	Recreation/agriculture/wildlife & livestock watering/fishery
	12. Big Horn to South Sheridan	Recreation/agriculture/wildlife & livestock watering/fishery
	13. South Sheridan to confluence	Body contact recreation/wildlife & livestock watering/agriculture
Prairie Dog	14. Entire length	Agriculture/wildlife & livestock watering/industry
Powder	15. Middle Fork	Recreation/agriculture/wildlife & livestock watering/industry/drinking water
	16. South Fork	Agriculture/wildlife & livestock watering
	17. North Fork	Recreation/agriculture/wildlife & livestock watering/fishery
	18. Mainstem (Sussex to Montana)	Recreation/agriculture/wildlife & livestock watering
Little Powder	19. Entire length	Agriculture/wildlife & livestock watering
Salt	20. Entire length	Agriculture/industry/wildlife & livestock watering

TABLE 10 Continued

River/Stream	Segment	Use(s)
Crazy Woman	21. Entire length	Recreation/agriculture/wildlife and livestock watering/fishery
Clear	22. In forest	Recreation/wildlife and livestock watering/fishery/drinking water
	23. Above Buffalo	Drinking water/recreation/wildlife and livestock watering/fishery/agriculture
	24. In Buffalo	Body contact recreation/agriculture
	25. Below Buffalo to Texaco Dam	Recreation/agriculture/wildlife and livestock watering/fishery/industry
	26. Texaco Dam to mouth	Recreation/agriculture/wildlife and livestock watering/fishery/industry
Piney	27. Entire length	Recreation/agriculture/industry/wildlife and livestock watering/fishery

Source: Assessment Report and Recommendations, PRAPO Planning Area, WRRI, p. 10.

Groundwater

Groundwater information in the three counties is more limited than are surface water data. A total of 263 water quality well records from the tri-county area are currently stored on the WRDS system. Other data are available in the literature. Table 11 presents some of the known groundwater sources in northeastern Wyoming.

Additional groundwater data are described in companion documents, "Water Quality Determinations Mined Lands Areas, Northeastern Wyoming" and "Drinking Water Survey, Story, Wyoming" prepared by WRRI.

TABLE 11

Groundwater Sources: Northeastern Wyoming

Geologic Period	Aquifer/ Formation	Common Range Depth (ft.)	Common Range Well Yield (gpm)	Common Range TDS (gpm)
Tertiary	Wasatch	40 - 1000	1 - 40	160 - 6620
	Fort Union	150 - 600	1 - 30	484 - 3250
Cretaceous	Lance	150 - 1200+	1 - 50	450 - 3060
	Fox Hills	200 - 2300	20 - 70	1240 - 3290
Pennsylvanian	Tensleep	240 - 6500	25 - 250	255 - 3620
	Minnelusa	240 - 6500	25 - 250	to 200,000[1]
Mississippian	Madison	500 - 7600	100 - 2000	290 - 3290

[1] Oil test waters.

Source: Department of the Interior, 1974

Historic and Projected Water Uses

Historic Uses

During the course of the two-year planning program the Water Resources Research Institute prepared projections concerning population and water demand in the three-county area for 1982 and 1997. Within this work effort, past water use estimates were undertaken for the various employment sectors as indicated in Table 12 . These estimates were developed by determining the AFW/E (acre feet of water divided by the number of employees) ratios. These AFW/E ratios combined with manufacturer's data for the years 1954, 1959, 1964, and 1968 were utilized to prepare estimated historic water use in acre feet for the three-county area.

TABLE 12

Water Use by Employment Sector in Acre Feet - PRAPO Area

Sector	1954	1959	1964	1968
Concrete-Gypsum Plaster	27,616	36,821	52,163	53,698
Fabricated Metal Products	346,732	135,011	159,558	208,653
Food and Kindred Products	1,890,150	1,914,698	2,332,004	2,488,493
Lumber and Wood Products	408,101	429,580	463,332	362,074
Furniture & Fixtures	21,479	9,205	9,205	12,274
Machinery Except Electrical	349,801	524,701	484,811	579,933
Electrical Equipment and Supplies	349,801	285,364	312,979	389,690
Transportation Equipment	708,306	797,791	742,559	960,417
Instruments and Related Productivity	58,300	70,574	88,984	116,600
Miscellaneous Manufacturing Industries	64,437	42,958	39,890	42,958

Source: Powder River Areawide Planning Organization, Population and Water Demand Projections for 1982 and 1997, Water Resources Research Institute, pp. 51-62, and Oblinger-Smith Corporation.

This same type of methodology was utilized to estimate the water consumption in the petrochemicals sector, the coal-energy sector, the synthetic fuels sector, steam electric generation sector and unit train transportation of coal out of the state. The AFW/E ratios when utilized with the number of employees in these various sectors, indicated that the water consumed in the petrochemicals industry had risen from 18,200 acre feet in 1967 to 23,000 acre feet by 1972 in the total Powder River Basin. A similar analysis indicated that there was no water consumed in the uranium industry in 1967; however, there were 868 acre feet of water consumed in 1972 for the same industry. In 1968, it was estimated that 3,000 acre feet of water was utilized for electric steam generation in the basin. Historically, no water has been utilized for synthetic fuels production in the Powder River Basin and negligible amounts have been used for the mining of bentonite, gypsum and cement. It is also estimated that trains have used only a negligible quantity of water in the transportation of coal outside of the state.

Future Water Demands

Demands were projected based on an analysis of the employment sector and projections in employment by sector. The water sector needs were then developed by determining future AFW/E ratios for the various sectors. The analysis and projection process was applied to three growth scenarios as follows.

Scenario I was defined as the zero growth scenario. The projections in this scenario assumed no additional growth in the coal-energy sector after 1975 and all other input data would remain unchanged.

Scenario II was defined as the "most likely" level of coal-energy growth which would occur during the study period. The basis for determining the most likely level of growth was left primarily with the city and county planners in their respective areas. After it was determined which developments seemed most probable, the base coal-energy employment figures associated with these developments were entered into the "Powder River Economic Simulation Model" and the appropriate population and water demand figures were obtained. In each instance, an attempt was made to outline the individual development involved, its time schedule, and the number and location of both construction and permanent employees. The individual projects were then summarized to arrive at the overall employment figures for the area, allowing for population and water demand figures to be estimated.

Scenario III was defined as a "high range" of development alternatives. This scenario generally portrayed the high level of development which was believed to be the highest possible development pattern under any normal set of circumstances, in the absence of war, etc.

The researchers indicated that the Powder River Economic Simulation Model was useful only at the aggregate county level. The estimates of population and water demands at the city level were obtained by making some estimates of the percent of the total county population living in a respective city or town. The remaining portions of this section indicate the projections utilizing Scenario II which appears to be the most logical or likely set of circumstances to occur in the three counties over the next 20 years.

Campbell County -

The domestic water demand for the City of Gillette was projected to amount to 8,898 acre feet of water by 1997 plus another 2,225 acre feet in the remaining portions of the County for a total county domestic water demand of 11,123 acre feet as shown in Table 13 . The total water demand for mining, manufacturing and domestic uses was estimated to amount to 193,392 acre feet for Gillette and Campbell County by 1997 as indicated in Table 14 .

TABLE 13

Scenario II

Domestic Water Demand - Campbell County

(Acre Feet)

	1980	1982	1990	1995	1997
Gillette	3,860	4,668	6,948	8,293	8,898
Remainder of County	1,152	1,394	1,960	2,204	2,225
Total Campbell County:	5,013	6,062	8,908	10,497	11,123
% Gillette	77	77	78	79	80

Source: Powder River Areawide Planning Organization, Population and Water Demand Projections for 1982 and 1997, Water Resources Research Institute, p. 74.

TABLE 14
Scenario II
Total Domestic, Mining, and Manufacturing
Water Demand - Campbell County
(Acre Feet)

	1980	1982	1990	1995	1997
Gillette	3,860	4,668	6,948	8,293	8,898
Remainder of County	108,990	141,312	166,674	179,493	184,494
Total Campbell County:	112,850	145,980	173,622	187,786	193,392

Source: Powder River Areawide Planning Organization, Population and Water Demand Projections for 1982 and 1997, Water Resources Research Institute, p. 75.

Johnson County -
As shown in Table 15 , the domestic water demand for the City of Buffalo would amount to 3,978 acre feet and 4,680 acre feet totally for Johnson County by 1997. In adding the mining and manufacturing water demand projected to amount to 68,781 acre feet for Johnson County, a total water demand of 73,461 acre feet by 1997 will be required (See Table 16).

TABLE 15
Scenario II
Domestic Water Demand - Johnson County
(Acre Feet)

	1980	1982	1990	1995	1997
Buffalo	1,441	1,646	2,834	3,652	3,978
Remainder of County	561	609	709	696	702
Total Johnson County	2,002	2,255	3,543	4,348	4,680
% Buffalo	72	73	80	84	85

Source: Powder River Areawide Planning Organization, Population and Water Demand Projections for 1982 and 1997, Water Resources Research Institute, p. 78.

TABLE 16

Scenario II

Total Domestic, Mining, and Manufacturing Water Demand - Johnson County

(Acre Feet)

	1980	1982	1990	1995	1997
Buffalo	1,441	1,646	2,834	3,652	3,978
Remainder of County	12,518	10,661	62,575	68,326	69,483
Total Johnson County	13,959	12,307	65,409	71,978	73,461

Source: Powder River Areawide Planning Organization, Population and Water Demand Projections for 1982 and 1997, Water Resources Research Institute, p. 79.

Sheridan County -

The domestic water demands for 1997 for the City of Sheridan are estimated to amount to 6,850 acre feet as indicated in Table 17 . The remainder of the County will demand 2,935 acre feet of water for a total County demand of 9,785 acre feet by 1997. The mining and manufacturing water demand is estimated to amount to 27,771 acre feet in the County, resulting in a total estimated demand of 37,556 acre feet by 1997 as shown in Table 18 . Of the three counties, Campbell County will require by far the most acre feet of water, based on Scenario II.

TABLE 17

Scenario II

Domestic Water Demand - Sheridan County

(Acre Feet)

	1980	1982	1990	1995	1997
City of Sheridan	3,385	3,856	5,188	6,340	6,850
Remainder of County	1,822	1,987	2,555	2,849	2,935
Total Sheridan County:	5,207	5,843	7,743	9,189	9,785
% City of Sheridan	65	66	67	69	70

Source: Powder River Areawide Planning Organization, Population and Water Demand Projections for 1982 and 1997, Water Resources Research Institute, p. 81.

TABLE 18

Scenario II

Total Domestic, Mining, and Manufacturing Water Demand - Sheridan County

(Acre Feet)

	1980	1982	1990	1995	1997
City of Sheridan	3,385	3,856	5,188	6,340	6,850
Remainder of County	22,733	19,950	25,265	29,364	30,706
Total Sheridan County:	26,118	23,806	30,453	35,704	37,556

Source: Powder River Areawide Planning Organization, Population and Water Demand Projections for 1982 and 1997, Water Resources Research Institute, p. 82.

The total amount of water available for irrigated agriculture will depend somewhat on those waters diverted for industrial and coal-energy development. Data are inadequate on the total water supply, although some estimates have been made. In projecting irrigated crop distribution and production, consideration was given to competition for water by the mineral sector. It was presumed in arriving at the irrigated lands projections that effeciency in irrigation practices will offset water losses to industry. Consequently, a near constant irrigated acreage was projected.

TABLE 19

Irrigated Agriculture Water Use

(Acre Feet)

	1980	1982	1990	1995	1997
Campbell County (2.1%)	3,617	3,620	3,641	3,655	3,661
Johnson County (35.3%)	60,793	60,851	61,210	61,442	61,535
Sheridan County (55.5%)	95,581	95,673	96,237	96,602	96,748

Source: Powder River Areawide Planning Organization, Population and Water Demand Projections for 1982 and 1997, Water Resources Research Institute, p. 95.

In summarizing the projections for water use for irrigation, it is expected that water use in acre feet would remain relatively constant through 1997 as indicated in Table 19 .

In summary, the research undertaken by WRRI indicates that coal-energy development will cause a greater demand for domestic water use and a much greater water demand for mining and manufacturing. Specifically, the greatest amount of water will be used for coal-gasification plants and coal-fired electric steam generating plants if these facilities are developed. As the water demand for industrial and domestic uses increases, there will be greater pressure placed on controlling the expansion of irrigated agriculture.

Identification and Extent of Present Water Quality Problems

Definition of Criteria and Standards

Water quality goals were described in Chapter 1 and are useful as an overview in maintaining water quality in the three counties. However, in an assessment of water quality, more precise criteria and standards must be utilized to undertake this task. The criteria or standards against which the water quality in these streams was measured can be found in Appendix A and B, respectively. Criteria differ from standards in that they represent suggested constituent limits for specified water uses, while standards are regulatory limits on a particular segment or parameter. The criteria list used in this evaluation was prepared from Quality Criteria for Water (EPA, 1976) and Water Quality Criteria (EPA, 1972). The recommended concentrations are designed to protect various organisms, community structures and/or a prescribed water use.

Two lists of water quality standards are included in Appendix B. The first is that list which was in effect as of July, 1977, while the second list was prepared from the recommended water quality standards provided by the Water Quality Division of the Wyoming Department of Environmental Quality (DEQ). With possible changes, this second list will be submitted to the State's Environmental Quality Council. If accepted, this list will become the water quality standards of the State.

Water Quality Assessment by Stream Segment

As indicated previously in this chapter, a total of 158 water quality stations was used to evaluate the stream segments in the three counties. Three different data storage and retrieval systems were used in the stream segment analysis. These were the Environmental Protection Agency's STORET system, Water Resources Data System (WRDS) and the data system established in conjunction with WRDS for the Powder River Areawide Planning Organization. Seasonal data retrieval from STORET allowed for comparisons of wet and dry periods for each of the years assessed. In order to minimize errors due to changes in laboratory techniques, only data collected since 1970 were used in this evaluation. The wet period was established as March to September of each year. Differences between seasons were assumed to result from nonpoint runoff during wet periods. Groups contributing data to STORET and Water Resources Data Systems include the United States Geological Survey, United States Forest Service, Department of Environmental Quality, Wyoming Game and Fish Commission, and the Environmental Protection Agency, among others. The Powder River Areawide Planning Organization's system consists of data collected by either Powder River Areawide Planning Organization or Wyoming Resources Research Institute personnel for this investigation. Focus was given to fecal coliforms sediment and salinity in the data collection. These were believed to be the dominant pollutants in the PRAPO area.

The results obtained in the survey of the 158 data stations can be found tabularized by stream segment, year and season in Appendix D of the Assessment Report and Recommendations prepared by WRRI. Descriptions of the water quality data for each basin follow.

Tongue River -

Water quality in the source to Dayton segment is among the best in the study area. A few criteria excesses were noted during the wet period but appear only occasionally. Only the raw water supply and aquatic life criteria are ever exceeded. These are the most restrictive of the possible uses. Natural sources and sampling error could account for the observed excesses. During the dry season the situation is similar for criteria excesses. A single criterion excess for fecal coliform was observed during the period of record. It appears that this observation represents an anomalous condition. Violations of the pH standard were observed in this segment as well as the other three segments of the stream. The origin of these violations are natural and do not exceed the federal criteria limits which are not as restrictive.

The Dayton to Monarch segment maintains generally similar water quality as the preceding segment. The collected data occasionally exceed specific criteria values for raw water and aquatic life. A single boron value in excess of agricultural criteria was observed.

An important potential pollution source in this segment is the backwash from the water treatment facilities at Ranchester. Recent samples collected by DEQ's Water Quality Division showed 11 mg/1. of aluminum in this effluent. At this time no definitive data are available to adequately describe the possible effects of this effluent upon the river.

Total dissolved solids indicated some increase through the first two segments, with low values of less than 100 mg/1. occurring in the first segment, usually during the month of June. High readings ranking between 300 to 400 mg/1. occurred in the second segment during the late winter months. In the Monarch segment, increases of suspended solids beyond the criteria level deemed acceptable for a good fisheries have been observed. These excesses generally occur during April and May and are believed to be caused by the flushing effect at the outset of spring runoff. Although the flushing action causes short duration excesses of the suspended solids criteria, the overall effect is probably beneficial since it removes accumulated solids from the stream bottom.

The Monarch to below Goose Creek segment is similar to prior segments. During the wet period the river meets all applicable criteria except aquatic life.

Between Goose Creek and the state line the water quality in the river changes rapidly. Increases in salts and coliforms as well as the specific criteria parameters were observed in this segment. With present data, it appears that Goose and Prairie Dog Creeks are mainly responsible for this alteration. Data obtained from USGS stations at Dayton, Monarch and Decker over a long period of time show increases in parameter concentrations of salt in the downstream direction. Figures 1 and 2 illustrate the relative locations of the major sources for coliforms as well as salts. The coliform data presented in Figure 1 confirm other reports which state that the majority of these organisms originate in Sheridan's sewage treatment plant. This figure also shows additional sources on the Tongue River itself in the vicinity of the State Route 338 bridge. These sources appear to be improperly operating septic systems and possibly some concentrated runoff from winter feeding pastures.

Figure 2 presents the approximate locations of the various salt sources along the river. This information indicates a sharp increase in total salts in the last segment of the Tongue River in the study area.

USGS data indicate that the average salinity concentration increases approximately 200 mg/l. in the Tongue River between Monarch and Decker. Salt loads increase approximately 345 percent in this reach while flow almost doubles. Salinity levels at the state line, however, have averaged less than 500 mg/l. since 1970 and have shown no tendency to increase during that period. Such levels do not cause impairment of any of the beneficial uses considered on this stream.

Table 20 compares the contributions of the various salt sources along the river. This table was prepared from USGS data and data collected for Prairie Dog Creek during the PRAPO monitoring program. It indicates that salt load contributions to the drainage from the Tongue River above Goose Creek and Prairie Dog Creek are approximately equal.

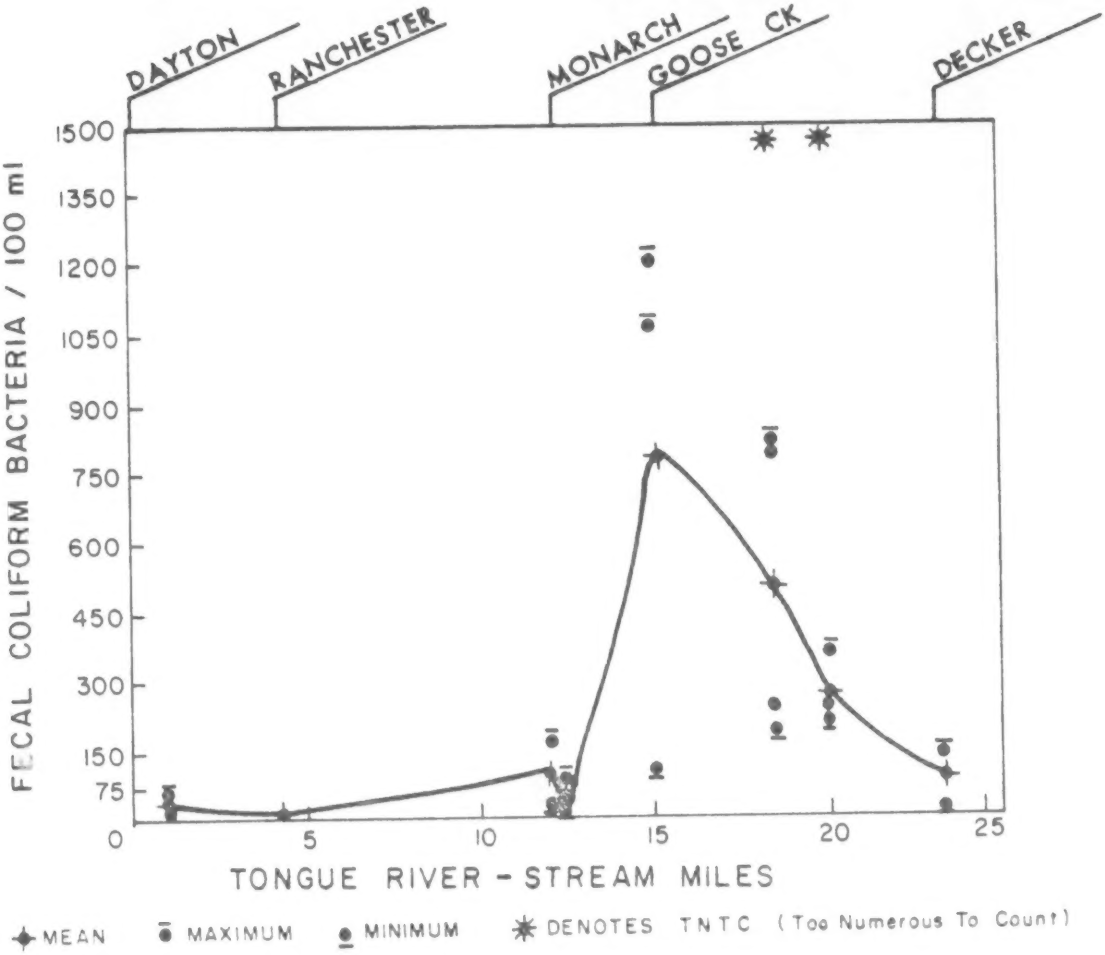
TABLE 20

Salt Sources: Tongue River

Contributors	Yield (T/D)	Background Level (T/D)	Percent of Total At Decker
Tongue River at Monarch	141	Same	29
Goose Creek	146	141	30
Prairie Dog Creek	128	287	27 approximately
Mainstem NPS	68	415	14
Tongue River at State Line		483	

Source: Assessment Report and Recommendations, PRAPO Planning Area, Water Resources Research Institute, p. 17.

Figure 1 - Fecal Coliform Distribution: Tongue River

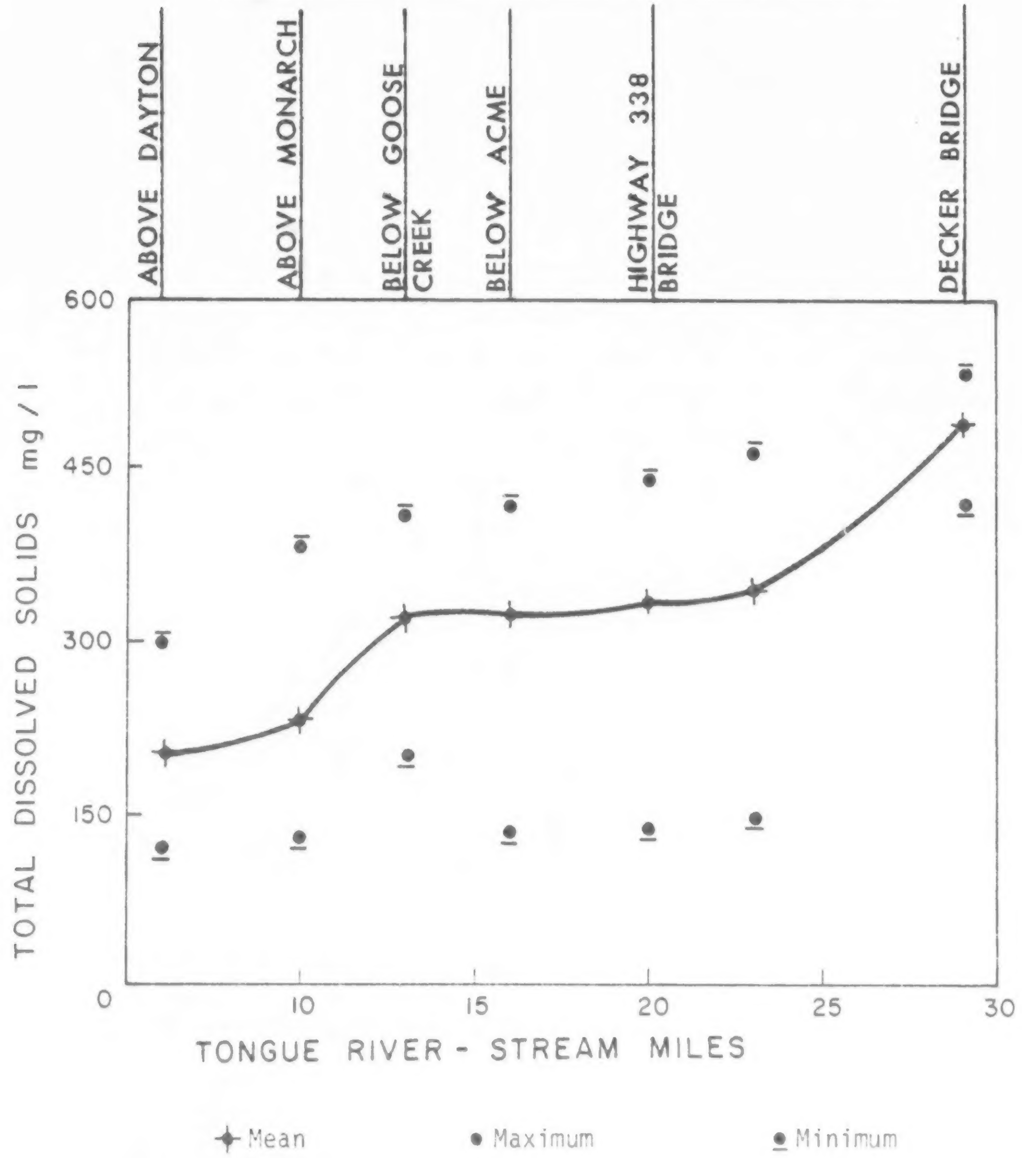


Note: The coliform and salinity data that were utilized in this analysis and illustrated on this figure and others in this section were obtained by PRAPO or WRRI over a two-year period. However, for this time period they are valid and representative.

Source: Assessment Report and Recommendations, PRAPO Planning Area. Water Resources Research Institute, p. 16.

According to USGS records, Goose Creek provides 36 percent of the average annual flow to the Tongue River at Decker, while Prairie Dog Creek provides nine percent. It would appear that while Goose Creek contributes significant salts to the Tongue River system, the percent contribution is approximately equivalent to the amount of flow added. This, however, is not true of Prairie Dog Creek. Its contribution of approximately 27 percent of the salt load is carried in only 9 percent of contributing flow. This would account for the sharp increase noted between the last two sampling points in Figure 2.

Figure 2 - Salinity Distribution: Tongue River



Source: Assessment Report and Recommendations, PRAPO Planning Area, Water Resources Research Institute, p. 16.

Although the primary contributors of soluble salts to the river are Prairie Dog and Goose Creeks, additional salts are contributed by other small tributaries and by coal mine discharges into the river. Sources of salinity along these tributaries are primarily of natural origin. The underlying geological formations are the Fort Union and Wasatch which are saline. Added to this is the fact that much of the area through which the tributaries pass has previously been mined and abandoned with little attempt at reclamation.

Tongue River Summary

Water quality in the mainstem of the Tongue River is generally good. Excessive concentrations of fecal coliforms and ammonia concentrations in excess of the criteria levels for acquatic life originating from Sheridan's sewage treatment plant, from improperly operating individual sanitary systems and possibly from field runoff were observed in the Goose Creek to state line segment.

Nearly 60 percent of the salt load within the drainage was found to be contributed by Goose Creek and Prairie Dog Creek. Sources of salinity within those drainages will be discussed in following sections. The major source of salinity along the mainstem of the Tongue River and its smaller tributaries is of natural origin. The underlying geological formations of the drainage from Dayton to the state line are the Lance Formation and Foxhills Sandstone, as well as the Fort Union and Wasatch Formations. Ground waters within these formations generally range between 500 and 1,500 mg/1. TDS. Runoff from and tributaries passing through spoil areas of the numerous abandoned mine sites are another source of salinity in the drainage. Studies conducted by the USGS on waters contained within abandoned mine pits in the area have shown TDS levels ranging from as low as 93 mg/1. to a high of 3,670 mg/1. Soil Conservation Service personnel indicate that the amounts of saline soils in Sheridan County are negligible. Irrigation is not considered a significant source of salinity in the drainage. Figure 3 substantiates that belief by graphically showing that in four of the six years considered, the total dissolved solids levels were higher during the periods of base flow in the winter months than they were during the low flow portions of the agricultural irrigation season in late summer. Salt concentrations are well below levels where an impairment of current uses (generally agriculture) were observed. Any future development of these waters should be carefully evaluated, however, to provide adequate protection for each possible use.

Goose Creek

The upper segments of Big and Little Goose Creeks maintain generally good water quality. Alkalinity concentrations less than the recommended minimum for aquatic life were observed but are expected in these waters, particularly during spring runoff when water has minimal contact with carbonate-bearing strata. A number of fecal coliform excesses were noted in the Big Goose segment above Sheridan.

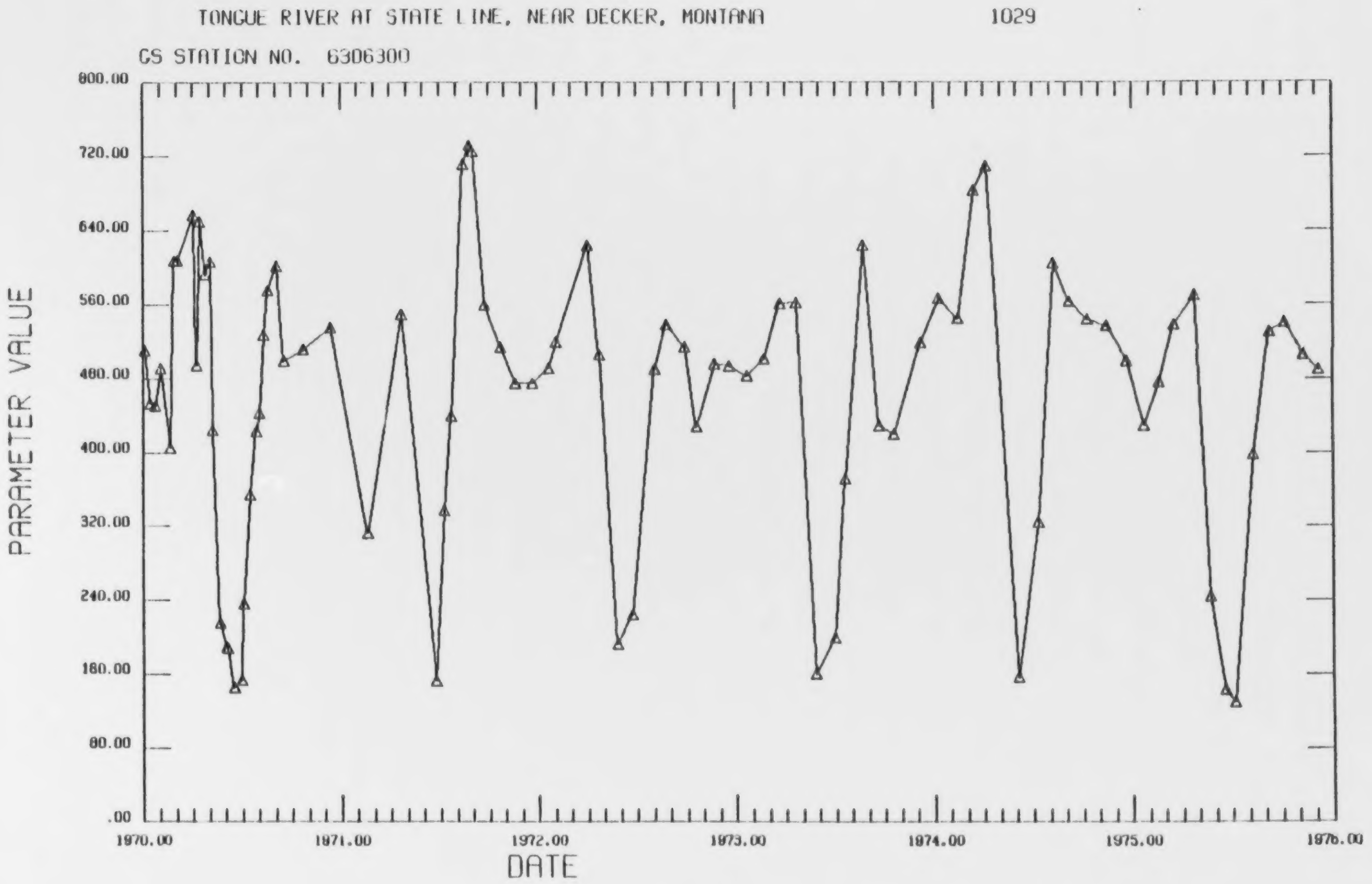
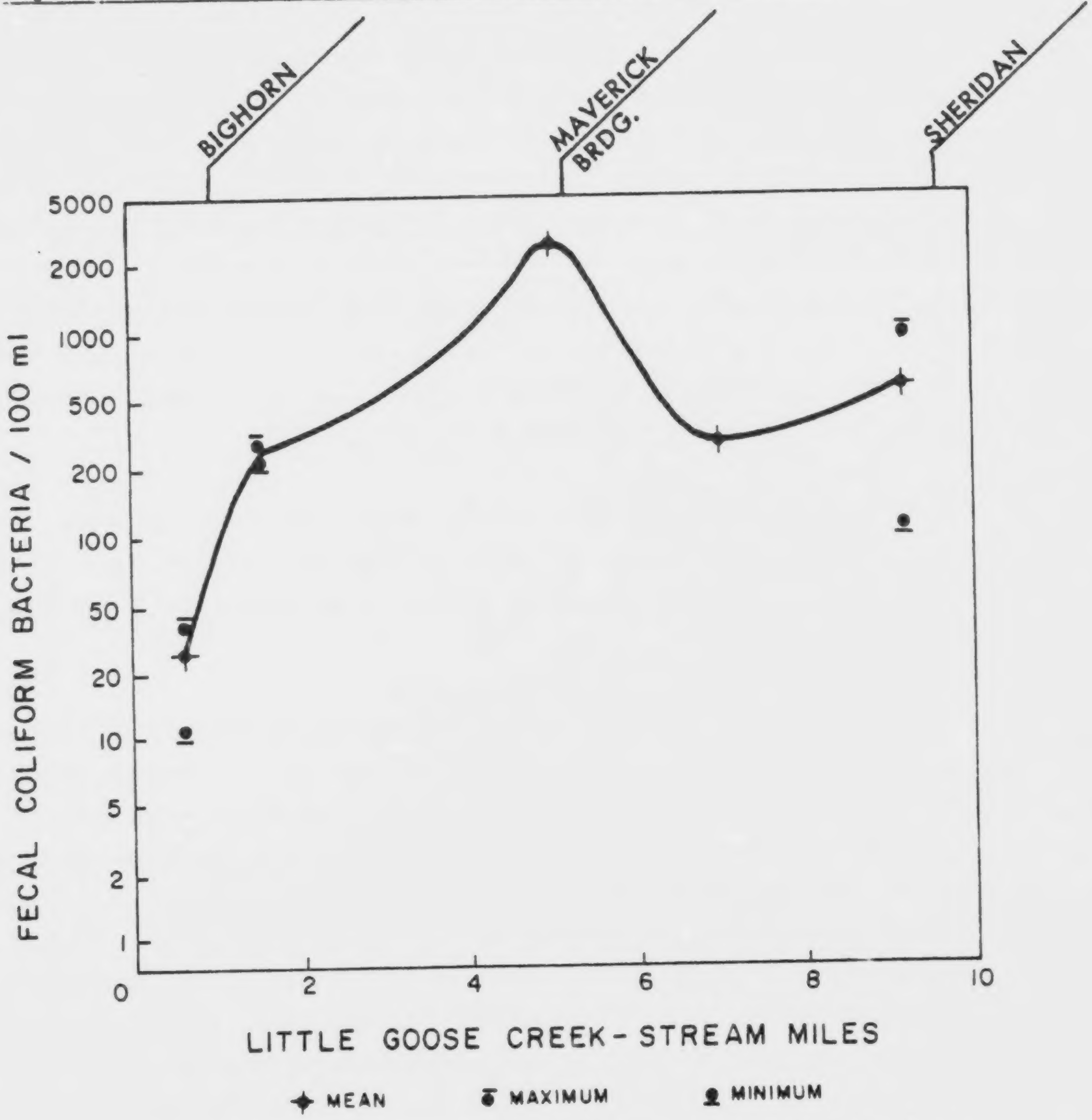


Figure 3. Total Salts: Tongue River at State Line, near Decker, Montana

Water quality in Big Goose Creek changes in the segments near Sheridan, while similar trends in Little Goose Creek begin to occur in the segment near Big Horn. Fecal coliform criteria excesses were observed in the vicinity of Big Horn. Degradation of both streams occur as they approach Sheridan. Increases in fecal coliform numbers and frequency were observed. Pollution sources appear to be improperly operating septic systems along the mainstems and in tributaries, and possibly some non-point source contribution from concentrated animal feeding areas. Figure 4 presents the approximate locations of coliform sources along the upper segments of Little Goose Creek.

Figure 4 - Fecal Coliform Distributuion: Little Goose Creek



Source: Assessment Report and Recommendations, PRAPO Planning Area, Water Resources Research Institute, p. 19.

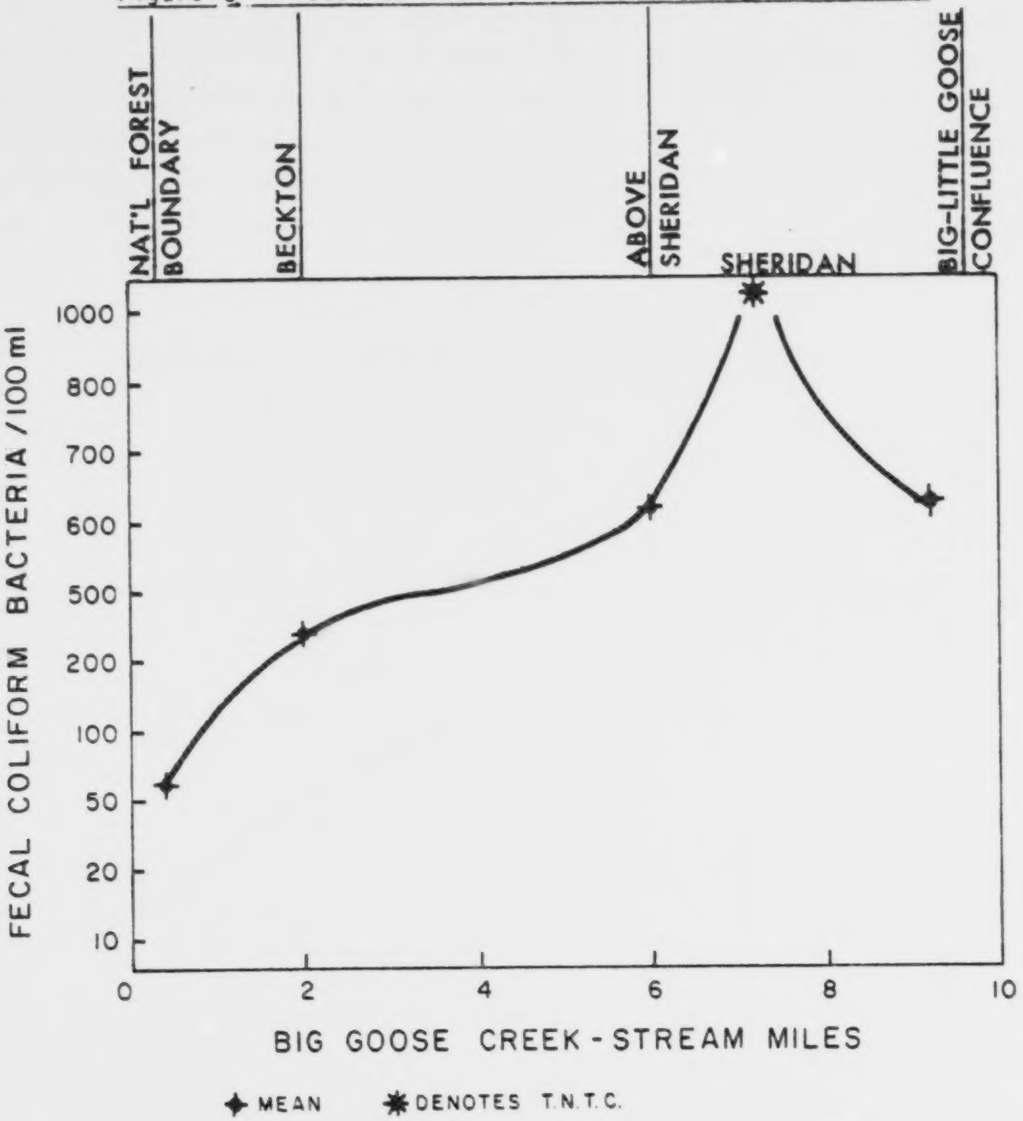
Figure 4 shows that organism concentrations exceed swimmable criteria of 200 organisms/100 milliliters (mls) for the entire stream length from Big Horn to Sheridan. Faulty or nonexistent septic tanks along the mainstem and tributaries are primarily responsible for these organism concentrations but non-point source runoff from fields and small feedlots may have some effect during the wet periods.

Associated decreases in dissolved oxygen concentrations along these same segments were also observed. Data collected during field reconnaissance studies revealed instances when dissolved oxygen concentrations in Little Goose Creek were between 2 and 3 mg/1. less than in Big Goose Creek, when measurements were made at the confluence. Dissolved oxygen levels in Big Goose Creek were above theoretical saturation during daylight hours, while Little Goose Creek was under-saturated. This appears to be due to the release of oxygen consuming effluents along the stream and the absence of various plant species in the channelized sections which could produce oxygen during daylight hours. Other research of the Water Resources Research Institute revealed a water quality standard dissolved oxygen violation for Goose Creek between the confluence and the city's sewage outfall. Dissolved oxygen levels of 5.0 mg/1. above the treatment plant were observed, while concentrations as low as 2.9 mg/1. were noted downstream from the sewage treatment plant.

Figure 5 presents similar data for Big Googe Creek above Sheridan. This figure shows that this section of the system is also adversely affected by fecal coliform concentrations resulting from similar situations experienced on Little Goose Creek.

Figure 6 presents the fecal coliform data for Goose Creek in and below Sheridan and indicates that the river segment below Sheridan is strongly influenced by the sewage treatment plant. Diurnal oxygen sags below water quality standards were commonly observed during this study, while fecal coliform violations resulting from the sewage treatment plant were common. Potentially toxic ammonia concentrations were also observed during wet and dry periods. Fish kills of carp and various sucker species were observed twice during summer, 1976. It is not known whether these kills resulted from decreased dissolved oxygen concentrations, toxic ammonia or some other unidentified problem. On one of those occasions, dead fish were observed in the stream between the Little-Big Goose confluence and the sewage treatment plant.

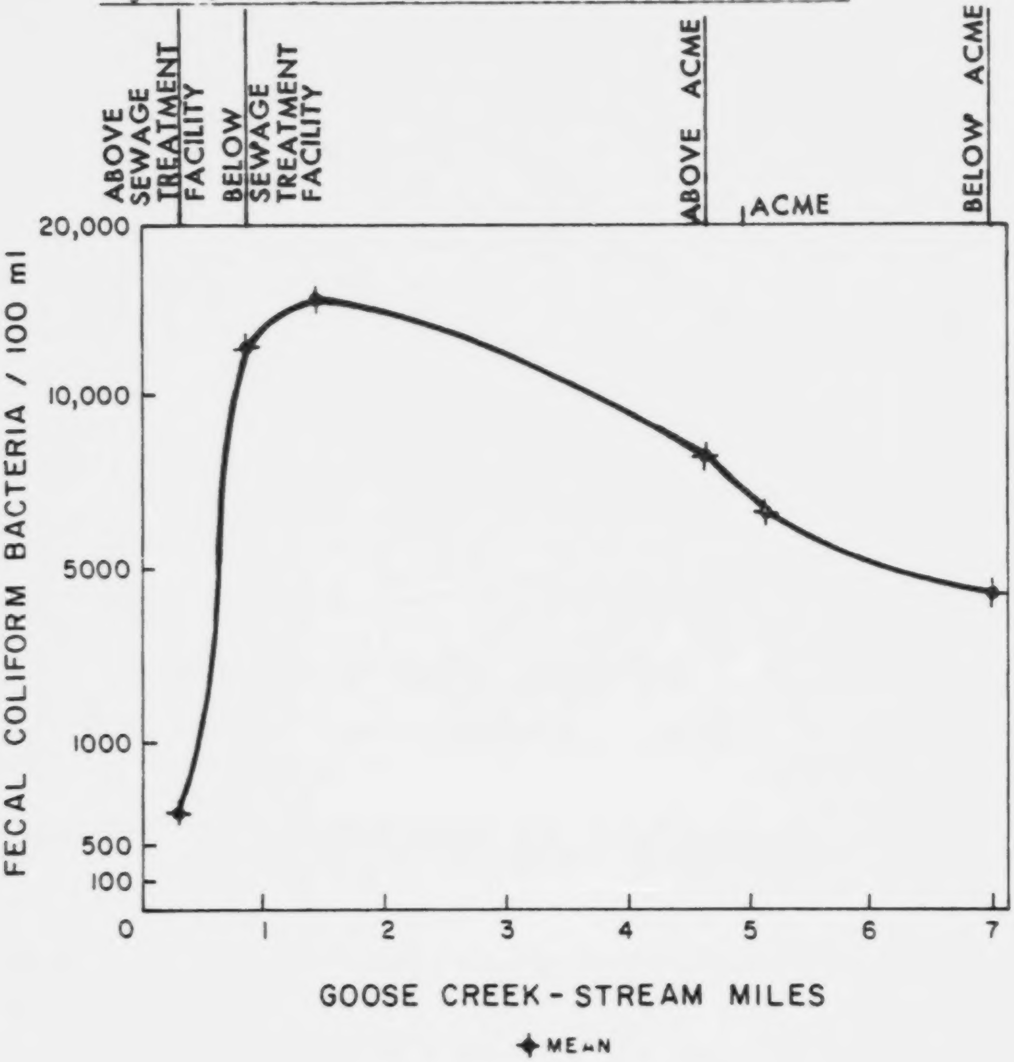
Figure 5 - Fecal Coliform Distribution: Big Goose Creek



Source: Assessment Report and Recommendations, PRAPO Planning Area, Water Resources Research Institute, p. 20.

Field studies indicate that most of the effects of the sewage treatment plant are no longer present in the Plachek pit to Tongue River confluence segment. Diurnal dissolved oxygen variations are less severe, ammonia was not observed and organic nitrogen levels approach similar levels of concentration on stream segments above Sheridan. Fecal coliforms, however, still exceed water quality standards. These organisms persist at levels violating water quality standards for a considerable distance in the Tongue River. Based on data from the USGS gage in Sheridan, the highest concentrations of total salts were observed during August. However, concentrations in late winter months approacned those of late summer suggesting that the most important contributors to salinity are natural conditions.

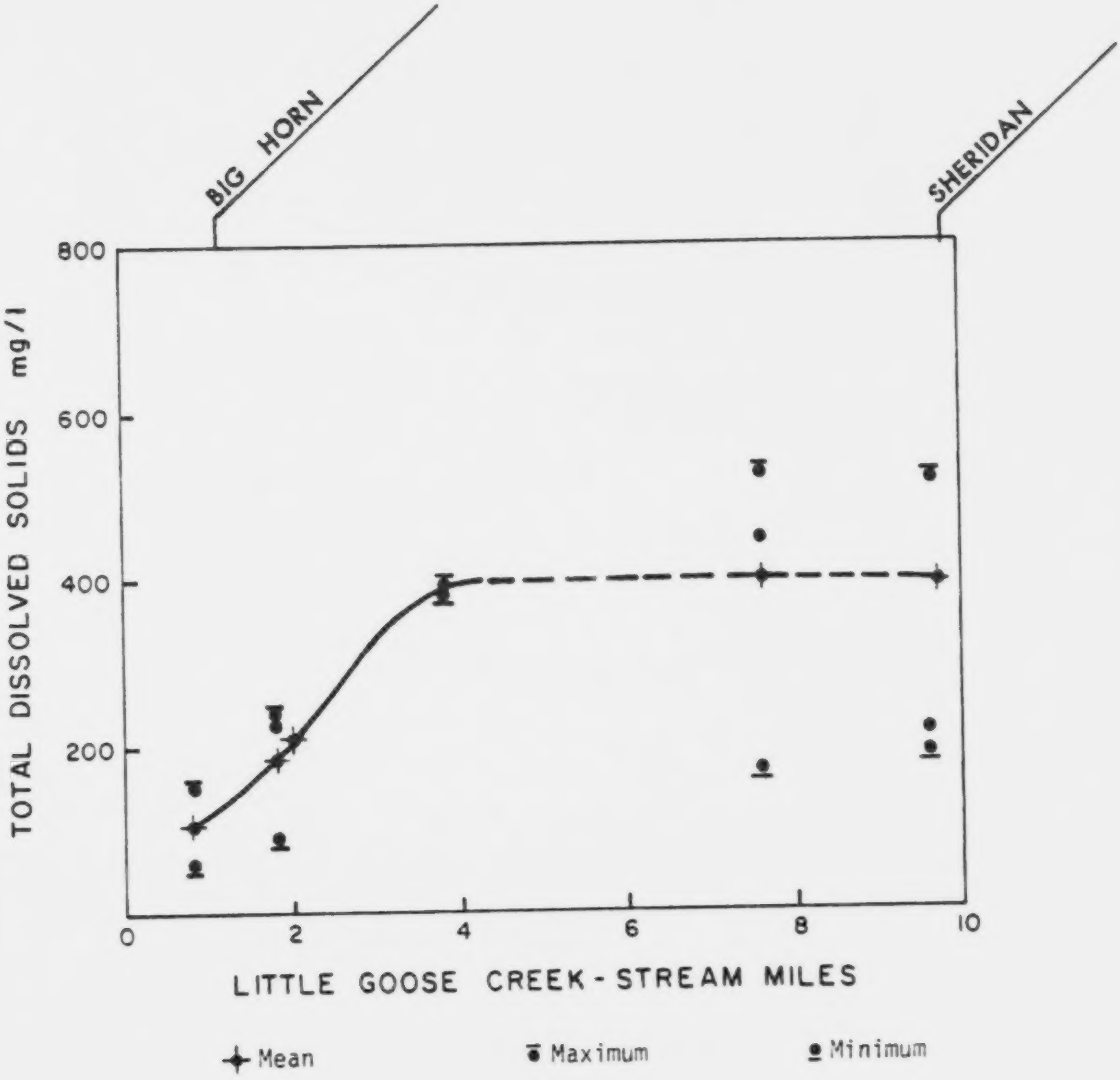
Figure 6 - Fecal Coliform Distribution: Goose Creek



Source: Assessment Report and Recommendations, PRAPO Planning Area, Water Resources Research Institute, p. 21.

Figure 7 illustrates the spatial salt contributions for Little Goose Creek. This graph shows that the majority of the salts enter the river around Big Horn and that average salt contributions level off at a point compatible with all water uses for the last six channel miles.

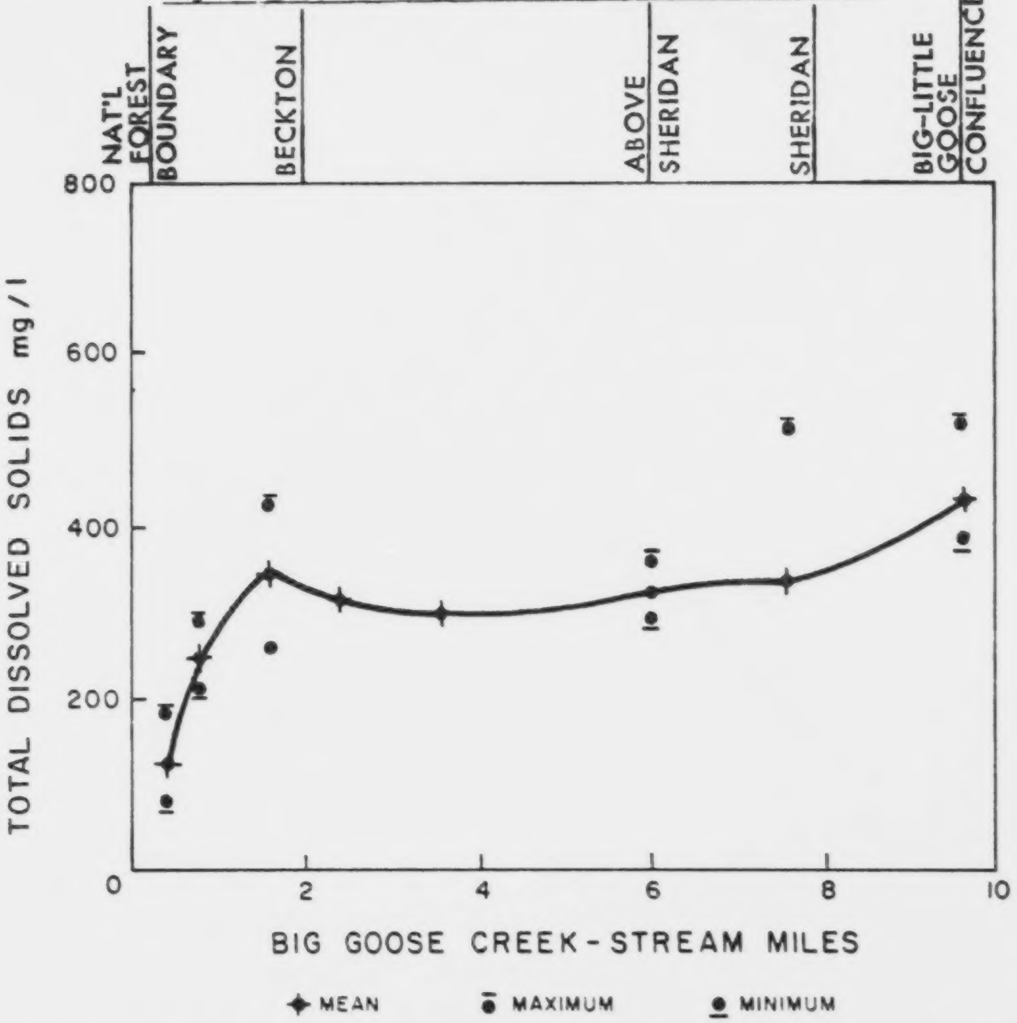
Figure 7 - Salinity Distribution: Little Goose Creek



Source: Assessment Report and Recommendations, PRAPO Planning Area, Water Resources Research Institute, p. 24.

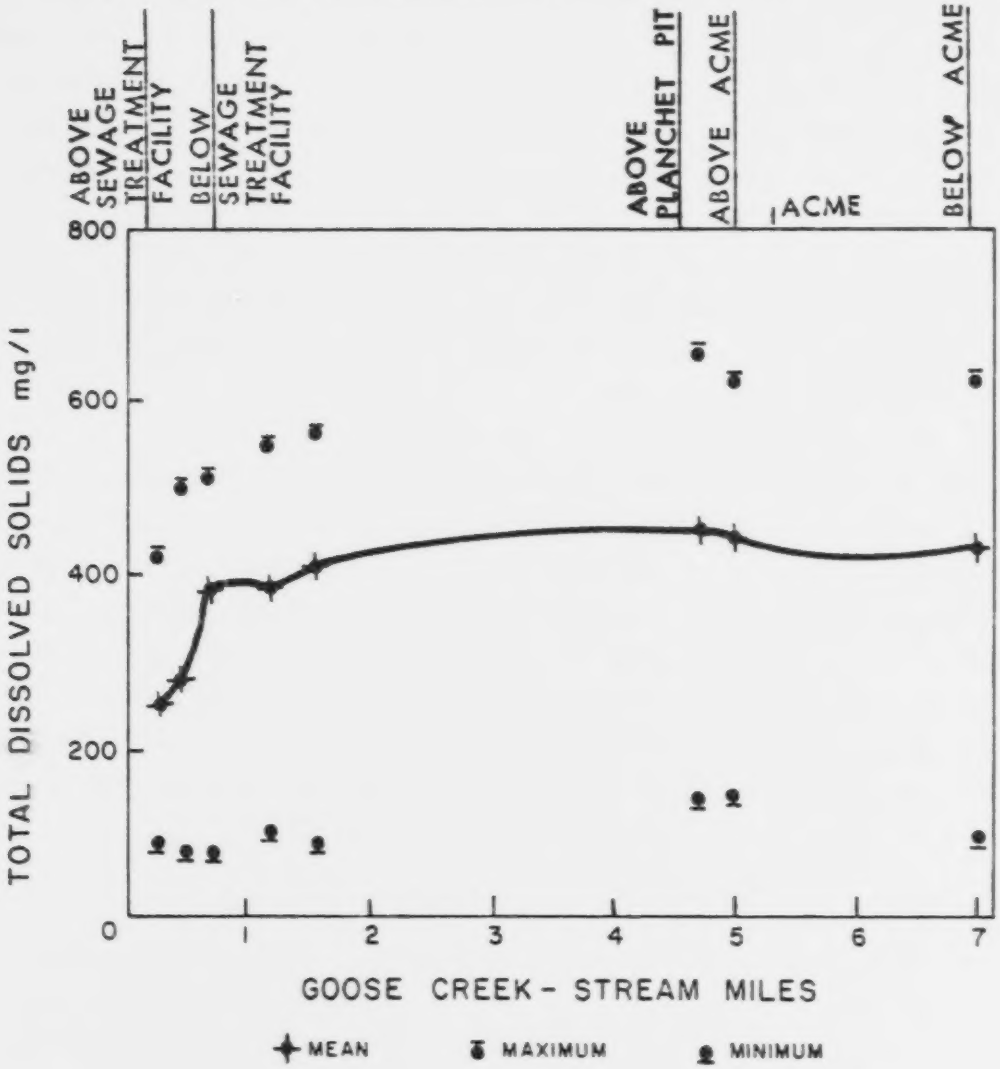
Figure 8 presents similar data for Big Goose Creek. Most of the salts are associated with the upper reaches of the river and appear to be natural in origin. Figure 9 presents the salinity profile for Goose Creek in and below Sheridan. The mean salinity concentrations stabilize at a point compatible with all uses. The highest concentrations observed appeared in most cases due to seasonal base flows compounded to some extent by irrigation return flows.

Figure 8 - Salinity Distribution: Big Goose Creek



Source: Assessment Report and Recommendations, PRAPO Planning Area, Water Resources Research Institute, p. 24.

Figure 9. - Salinity Distribution: Goose Creek



Source: Assessment Report and Recommendations, PRAPO Planning Area, Water Resources Research Institute, p. 25.

Goose Creek Summary

The addition of treated and untreated sewage to the Goose Creek system is the biggest problem of the drainage. The largest source of this pollution is the Sheridan Sewage Treatment Plant, however improperly functioning or non-existent septic systems are also significant sources, especially along Little Goose Creek. These pollution sources cause high levels of fecal coliforms and ammonia. In some instances they also can cause reduced oxygen levels below the level necessary to maintain aquatic life.

Sharp increases in salinity were also reported in this stream system although even at the highest concentrations they are well below levels which would impair current beneficial uses of the water, particularly irrigation use. The sharp increases occur, in the cases of both Little Goose Creek and Big Goose Creek, close to the foot of the mountains. In both streams the increases range from approximately 100 mg/1. TDS to 400 mg/1. TDS over a distance of less than five miles. It is at this point that these streams pass through a number of saline geological formations such as the Cody Shales and Frontier, Lance and Chugwater formations. As the streams flow towards Sheridan, salinity levels remain approximately the same.

Figure 10 presents the yearly distribution of total salts at the USGS station in Sheridan. High salinity concentrations occur twice during the year, during the winter base flow period and during low flow period of the irrigation season. The winter peak values from 1970 through 1975 averaged 528 mg/1. TDS while concentrations during the summer low flow period averaged 587 mg/1. TDS. The winter base flow concentrations are considered to be from natural sources. The difference between the two peaks of 59 mg/1. TDS could be from irrigation return flows, although the higher evaporation rate during the summer months should also be taken into consideration.

Prairie Dog Creek

Very little data are available to describe the overall water quality in this river system. From what data are available, indications are that high salinity levels have the greatest potential for creating water quality problems in this drainage. At present, concentrations have not reached a level which would cause use impairment. The lack of data makes it impossible to determine trends within the drainage but concentrations are high enough that concern must be raised. An insufficient data base also prevents analysis of salinity levels over a yearly distribution pattern. However, monitoring completed by USGS, at their gage station in August, 1976 showed a concentration of 1,040 mg/1. TDS, while PRAPO collected samples at the same station in December, 1976 contained 1,250 mg/1. TDS. This tends to indicate that most of the salinity is of natural origin. Underground recharge through the saline Fort Union and Wasatch Formations is believed to be the largest contributor. The mainstem of Prairie Dog Creek and its tributaries rise in the foothills and plains rather than the mountains and receive most of their flow from ground waters.

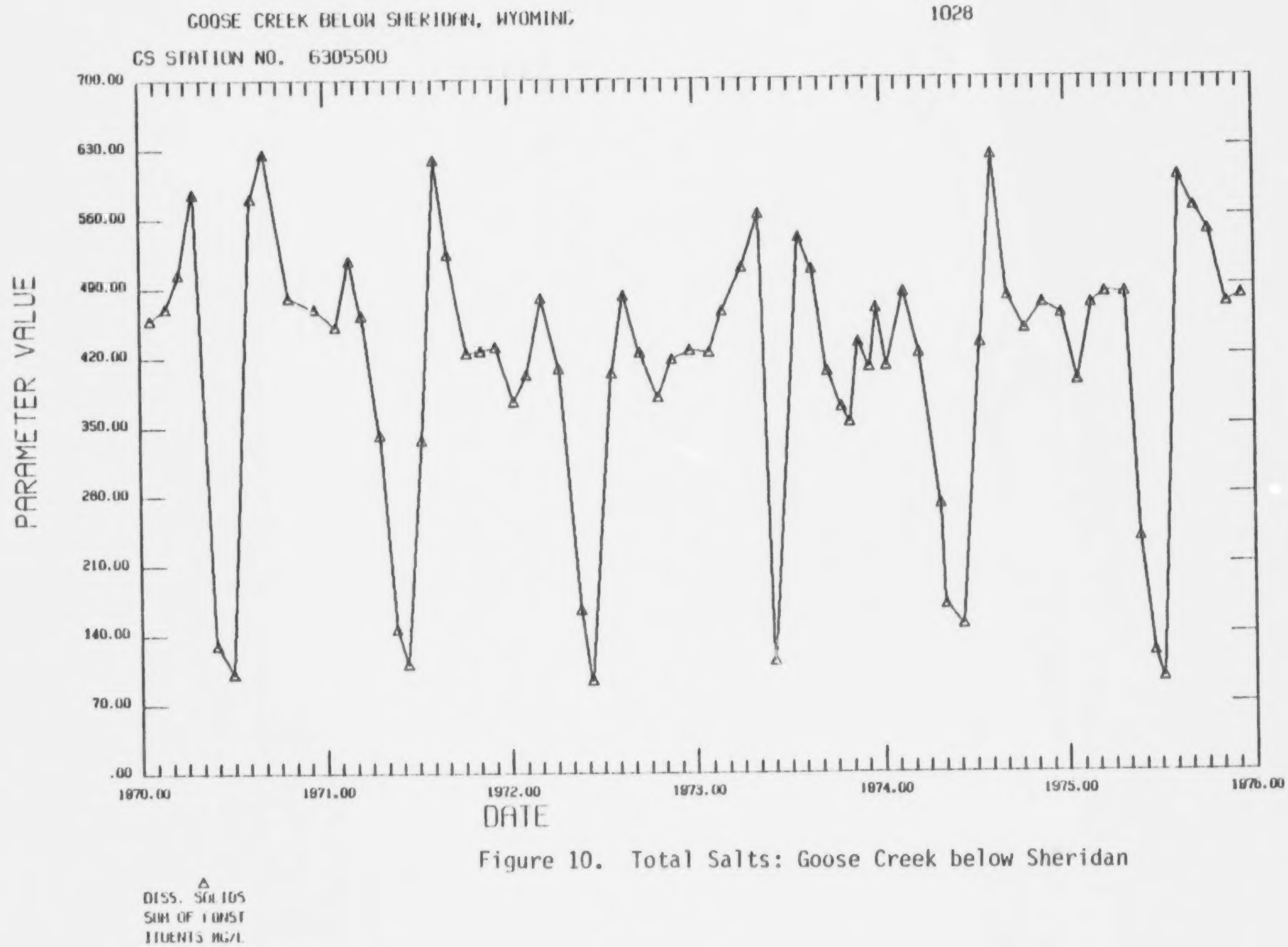


Figure 10. Total Salts: Goose Creek below Sheridan

During the irrigation season waters from Piney Creek are diverted into Prairie Dog Creek. Addition of these waters may result in the dilution of salinity concentrations in Prairie Dog Creek during the irrigation season rather than raising the concentrations.

Tributaries provided 43 percent of the total salt load, while non-point sources along the mainstem contributed 57 percent during PRAPO scheduled sampling events. Table 21 itemizes the approximate tributary and mainstem non-point source salt yields within this watershed.

TABLE 21

Salt Contributors: Prairie Dog Creek

Contributors	Yield (T/D)	Background Level (T/D)	Percent of Total at Mouth	Flow
Jenks Creek	51	27	21	42%
Meade Creek	7	78	3	7%
Wildcat	26	85	11	7%
Dutch	20	111	8	4%
non-point source	114	131	47	35%

Source: Assessment Report and Recommendations, PRAPO Planning Area, Water Resources Research Institute, p. 26.

Although Jenks Creek provided 21 percent of the salt load, it also provided 42 percent of the flow. Total dissolved solids concentrations were three to four times higher for Wildcat Creek and Dutch Creek than they were for Jenks Creek and Meade Creek. Both Wildcat and Dutch Creek are located in the plains area of the drainage and except during storm events derive all their waters from groundwater sources.

Prairie Dog Creek Summary

Although limited data are available to describe the water quality in this stream system, it appears as if the most potentially severe water quality problem is salinity present in the tributaries and lower reaches of the drainage. The present levels, however, are not now impairing the beneficial uses of the water.

Groundwater recharge through naturally saline geological formations is believed to be the major contributor to the high salinity levels in the Prairie Dog Creek drainage. The lack of a proper data base on this drainage hinders the opportunity to conduct a proper analysis of the problem. A more intensive and extended monitoring program is needed before trends can be detected.

Powder River

Very little data are available to describe the water quality in the North and Middle Forks of the Powder River. Generally, waters of excellent quality can be found in the upper reaches of each watershed. These areas are underlain by Paleozoic and Pre-Cambrian strata which are highly resistant to erosion. No water quality excesses were observed in the examined data for the upper reaches of either stream.

Areas bordering the mountains are underlain by Mesozoic rocks. These areas are subject to natural channel erosion and contribute much of the suspended sediment discussed in the basin. Earlier studies (1952) indicate a five-fold salinity increase in Middle Fork waters between Barnum and Kaycee. Sulfate replaces bicarbonate as the predominant ion. The available data, however, report no water quality standard violations (except pH for 1974 standards) or criteria excesses in the source to Kaycee stream segment of the Middle Fork and the North Fork of the Powder River.

Below Kaycee criteria excesses and standards violations have been recorded. Excesses of boron (1), ammonia (1) and iron (2) were recorded in 1976 while five excesses of the fecal coliform criteria have been recorded in the years 1974, 75 and 76. Three of these excesses also violated the Wyoming Water Quality Standard for fecal coliform bacteria. Excesses of iron and boron are believed to be of natural origin. Ammonia and fecal coliform bacteria excesses are caused by the discharge of improperly treated sewage from Kaycee's sewage treatment facility.

The waters of the South Fork Powder River have on a number of instances exceeded the criteria levels for body contact recreation, stock watering and aquatic life. Of the nine separate criteria exceeded, only three were exceeded more than one time. They included the aquatic criteria for mercury (2) and iron (3). The six criteria excesses which were found only once are believed to be of natural origin and anomalous occurrences. The mercury and iron excesses are also believed to be from natural sources but are believed to be capable of recurring. The body contact criteria for fecal coliform bacteria was exceeded a total of three times. Only one of these excesses violated the 1974 Wyoming Water Quality Standards. The excesses are believed to be caused by livestock and/or wildlife grazing near the stream.

Salinity levels in the South Fork drainage are very high, averaging 2,742 mg/l. TDS from 1974 through 1976, based on USGS water quality records. These high values do not presently effect any beneficial use of these waters. Irrigation is negligible in the South Fork drainage and most of the water used for irrigation along the mainstem Powder River is diverted prior to the confluence of the South Fork and Main Stem. Flows in the South Fork during the months of August, September and October are often less than one cubic foot per second.

Approximately 81 tons of salts per day, based on USGS records 1974 through 1976, flow from the South Fork. Of this amount, 14 percent or 11 tons per day are contributed by the seven point source discharges in the drainage located at various petroleum production facilities. The remaining 86 percent is contributed by natural sources. The South Fork drainage contains 40 to 50 percent saline and alkaline soils and exposed shales. About 72 percent of the drainage is underlain with the very highly saline Frontier formation and Cody shale. The rest is underlain by other highly saline formations such as Chugwater, Mowrey and Thermopolis shales.

Salt Creek rises in Natrona County and flows northward to enter the Powder River just west of Sussex. It is by nature an ephemeral stream, however extensive petroleum production activities in the drainage area discharge enough water to maintain a flow in the stream below the town of Midwest. Criteria excesses in this drainage include boron (6), iron (3), ammonia (3), pH (1), and dissolved oxygen (1). The greatest problem however is the extremely high levels of total dissolved solids as well as dissolved solids constituents such as chlorides and flourides. Very high sodium absorption ratios were also observed which would interfere with irrigation, however there is very little irrigation in this drainage. Currently the waters of Salt Creek are suitable for wildlife and stockwatering only and have very often shown excesses of dissolved solids criteria for this beneficial use.

There are presently over forty point source discharges from oil treaters in the drainage that are under the national point source discharge elimination system permitting program. Discharge monitoring data show that these point sources discharge a total of 41.35 cubic feet per second at an average total dissolved solids concentration of 4,535 mg/1. The salt load from these discharges equals 460 tons per day. The average results from data collected at the USGS station on Salt Creek, however, are quite different. Average flow from 1974 through 1976 equaled 30 cubic feet per second with a total dissolved concentration of 4,405 mg/1. and a salt load of 336 tons per day. The point source discharges account for well over 100 percent of the discharge and salt load. The difference between the two sets of figures can be attributed to two things, the first of which is the possibility of error in sampling results caused by many different people undertaking the sampling of the various point source discharges. The second reason which probably accounts for most of the difference is the fact that the discharges average less than one cubic foot per second and are usually discharged into dry draws, where much of the water percolates into the ground or evaporates into the atmosphere.

The Sussex to Montana segment of the Powder River records the highest number of different parameters (16) which were in excess of criteria levels or in violation of Wyoming Water Quality Standards. The water uses, which the various parameters were in excess of the criteria limits include, aquatic life, irrigation, stock and wildlife watering and primary contact recreation. Of the sixteen parameters in excess, eleven of them maintain only one or two excesses recorded over the eight year period examined. These include flouride (1), boron (2), arsenic (1), radium 226 (2), cadmium (2), lead (2), manganese (1), aluminum (2), cyanide (1), and pH (2). Natural sources are believed to be the origin of these criteria excesses, as well as the three iron criteria excesses and the six mercury criteria excesses. A total of five dissolved oxygen criteria, ten ammonia criteria and thirteen fecal coliform criteria excesses were also reported for this stream segment during the same eight year period. Exact sources of these excesses are unknown, however, it is believed that inoperable or non-existent septic systems at household units located along the stream, especially in the area of Arvada, and livestock and wildlife grazing along the stream are the most likely sources of the fecal coliform and ammonia excesses. The hydraulic parameters of the lower Powder River and the climatic conditions during the summer months are the primary reasons for the low dissolved oxygen levels observed. These low levels may also be aggravated by the amount of organic material entering the stream from the sources previously mentioned. The excesses of pH, radium 226, dissolved oxygen and six of the thirteen fecal coliform bacteria excesses were in violation of Wyoming Water Quality Standards.

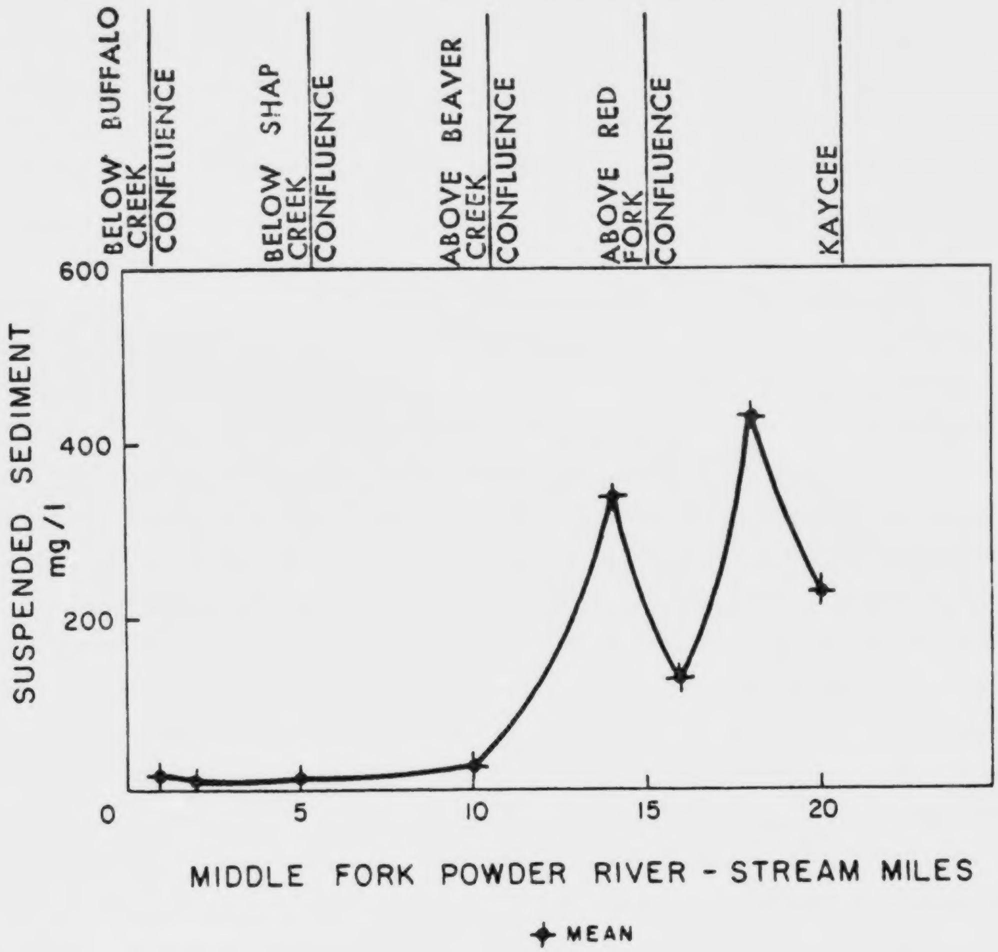
The Wyoming Game and Fish Commission manages this lower segment as channel catfish fishery. Other warm water fish species are located in this segment which require warm turbid waters. Reservoir projects on other drainages have eliminated these species.

Figure 11 presents suspended sediment data collected to evaluate the sediment yields from active and abandoned bentonite mine pits along the river. Examination of the area revealed that most of the pits are located at a sufficient distance from the river to make increased sedimentation unlikely.

Downstream settling and dilution are observed in the section between the Beaver Creek confluence and Kaycee. Table 22 presents approximate tributary and nonpoint contributions for sediments in this segment.

These data were collected during the later stages of runoff events and appear to be respresentative of the general condition. Total tributary contributions equal 49 tons of sediment/day. The amount measured at Kaycee amounted to 103 tons/day. The unaccounted 54 tons/day appear to arise from channel erosion as no sheet or unconfined runoff was observed anywhere in the study area during sampling.

Figure 11 - Sediment Distribution: Middle Fork Powder River



Source: Assessment Report and Recommendations, PRAPO Planning Area, Water Resources Research Institute, p. 30.

TABLE 22

Sediment Sources: Middle Fork Powder River

Contributor	Yield (T/D)	Background Level (T/D)	Percent of Total at Kaycee
Sediments:			
Buffalo Creek	4.0	4.0	4
Sheep Creek	0.2	8.0	4
Beaver Creek	25.0	33.2	24
Red Fork	16.0	49.2	16
Non-Point Sources	54.0	103.2	52

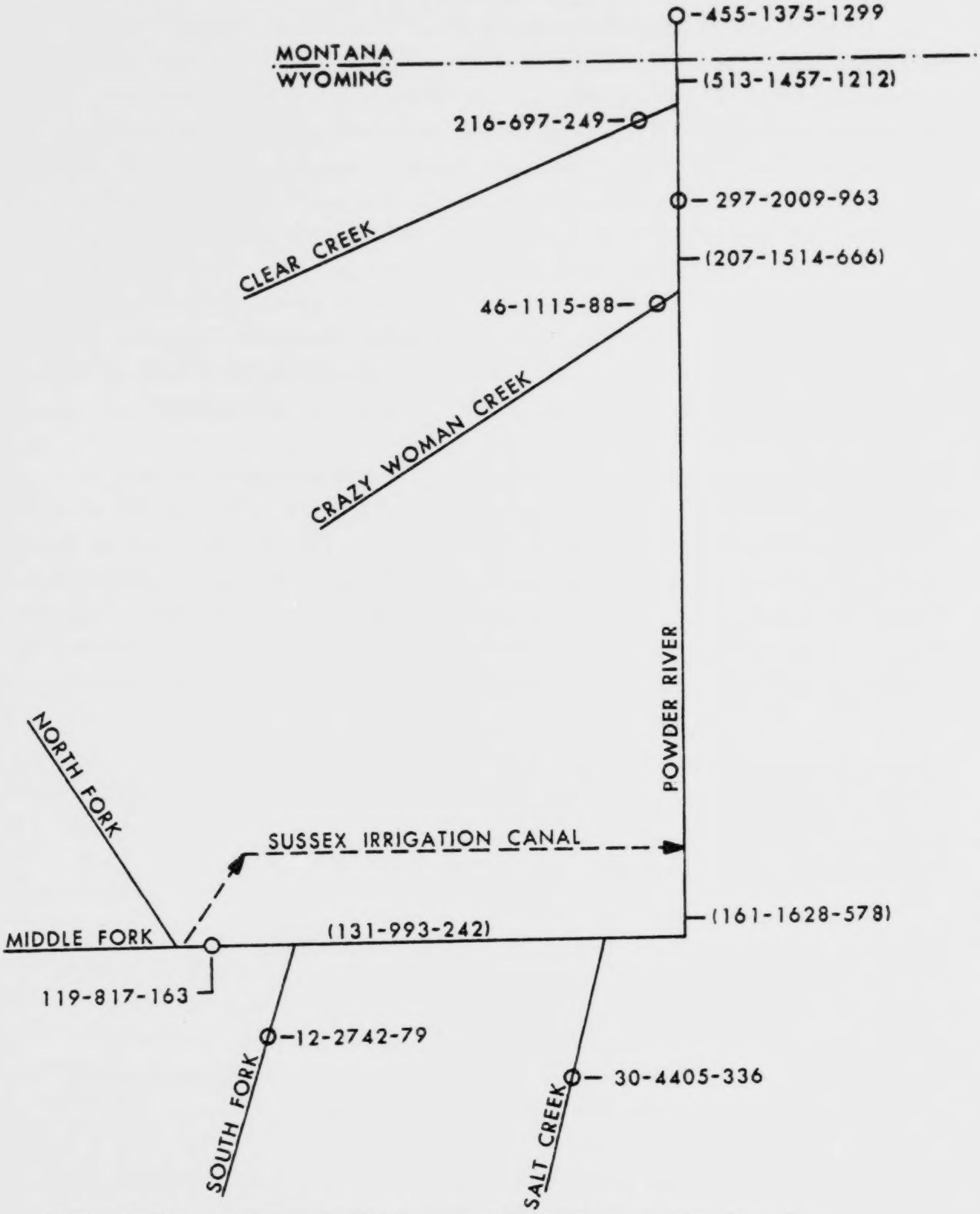
Source: Assessment Report and Recommendations, PRAPO Planning Area, Water Resources Research Institute, p. 31.

Based on data concerning long-term sediment concentrations at the USGS gage at Arvada, the greatest concentrations of suspended sediment in the Powder River occur during runoff seasons. If sediment concentrations in this drainage were lowered to a point compatible with other drainages in the PRAPO planning area, it is possible that various fish species which have evolved in the warm, turbid waters would be lost.

Figure 12 schematically diagrams the salinity profile of the Powder River and its tributaries. The six major tributaries to the river account for 915 tons of salt per day or 71 percent of the 1,299 tons per day average measured at the USGS station at Moorhead, Montana, based on USGS water quality records for the years 1974 through 1976. Salt Creek and Clear Creek contribute the greatest amounts of salts to the river, 26 percent and 19 percent respectively. Salt Creek's load of 336 tons/day is carried by an average flow of 30 cfs at a mean concentration level of 4,405 mg/1. TDS, which increases the concentration level in the Powder River from 993 mg/1. to 1,628 mg/1. total dissolved solids based on tributary contribution only. Clear Creek has the opposite effect on the Powder River. Its 249 tons/day salt load is carried by a mean discharge of 216 cfs at a concentration level of 697 mg/1., dropping the average total dissolved solids concentration in the Powder River at Moorhead, Montana to 1,375 mg/1. Between Kaycee and Arvada, non-point sources along the mainstem and ungaged tributaries account for 297 tons of salts per day, while the same sources account for 87 tons per day between Arvada and Moorhead. The drainage area south of Arvada has the greatest impact on high salinity levels in the Powder River. Natural sources, and man-related point and non-point sources are all contributors to the salt load in this section of the Powder River. Of the 417 tons of salt per day contributed by South Fork and Salt Creek, approximately 347 tons per day come from oil treater point source discharges. The remaining 70 tons per day are from natural sources in the South Fork drainage.

The North Fork and Middle Fork of Powder River contribute an average of 163 tons of salt per day carried in a flow of 119 cubic feet per second at a concentration of 817 mg/1. total dissolved solids. This information is based on data collected at the USGS water quality station on the Powder River near Kaycee, Wyoming. The gage station, however, is located immediately below the headgate for the Sussex Irrigation Canal and does not reflect the irrigation waters which are diverted from the river and re-enter as return flows below the gage station.

Figure 12 - Schematic Profile-Tributary Salt Loads to Powder River


-455-1375-1299
MONTANA
WYOMING
-(513-1457-1212)
216-697-249-
- 297-2009-963
CLEAR CREEK
-(207-1514-666)
46-1115-88-
CRAZY WOMAN CREEK
POWDER RIVER
NORTH FORK
SUSSEX IRRIGATION CANAL
MIDDLE FORK
(131-993-242)
-(161-1628-578)
119-817-163
-12-2742-79
SOUTH FORK
- 30-4405-336
SALT CREEK

NOTE: Number sequences indicate: mean instantaneous flow in c.f.s. - total dissolved solids concentration in mg/l - mean salinity in tons/day. The number sequences in parentheses are derived, based on tributary contributions only.

○ - U.S.G.S. water quality station

There are five point source discharges from oil treaters in the North Fork drainage; they account for 10 tons of salts per day. Natural sources and irrigation return flows account for the remaining contribution. Figure 13 represents the yearly distribution of total dissolved solids at the water quality station on the Powder River near Kaycee. During the winter base flow period, TDS peak concentration averaged approximately 925 mg/l. while peak concentrations during the late irrigation season averaged approximately 1,175 mg/l. The difference of 250 mg/l. is a 27 percent increase over the winter base flows. The increase is believed to be primarily attributable to higher TDS concentrations in irrigation return flows along the Middle and North Forks of the Powder River, and the higher evaporation rate during the summer months which would have a concentration effect on TDS levels in the streams.

The waters of Crazy Woman Creek, although they add an average of 88 tons of salt per day to the Powder River, have an overall dilution effect on the total dissolved solids concentration of the river. Since 1972, the peak concentration of total dissolved solids has averaged 1,468 mg/l. while the peak concentration during the irrigation season has averaged 1,848 mg/l., for an increase of 26 percent. The increase of 380 mg/l. is again reflective of the use of the waters for irrigation, as well as the higher evaporation rate during the summer months.

Between 25 percent and 40 percent of the alluvial soils in the upper portions of the drainage, including portions of the North, Middle and South Forks of Crazy Woman Creek and Poison Creek are saline or alkaline. It is in this area where the largest amount of irrigation in the drainage is found.

Figure 14 shows the same type of relationship between winter peak concentrations and summer peak concentrations on the Powder River at Arvada as exists on the North and Middle Forks of the Powder and on Crazy Woman Creek. Concentrations average 21 percent higher during the summer. The increase percentage-wise is lower than on the tributaries because of the buffering effect caused by the more constant salt loads from Salt Creek.

Between Kaycee and Arvada a salt load of approximately 300 tons per day enters the river from sources unaccounted for. This is based on data which show an average of 963 tons per day has been measured at Arvada while average salt loads from tributaries total only 666 tons per day. The sources of this contribution are believed to be very similar to those found in the tributaries.

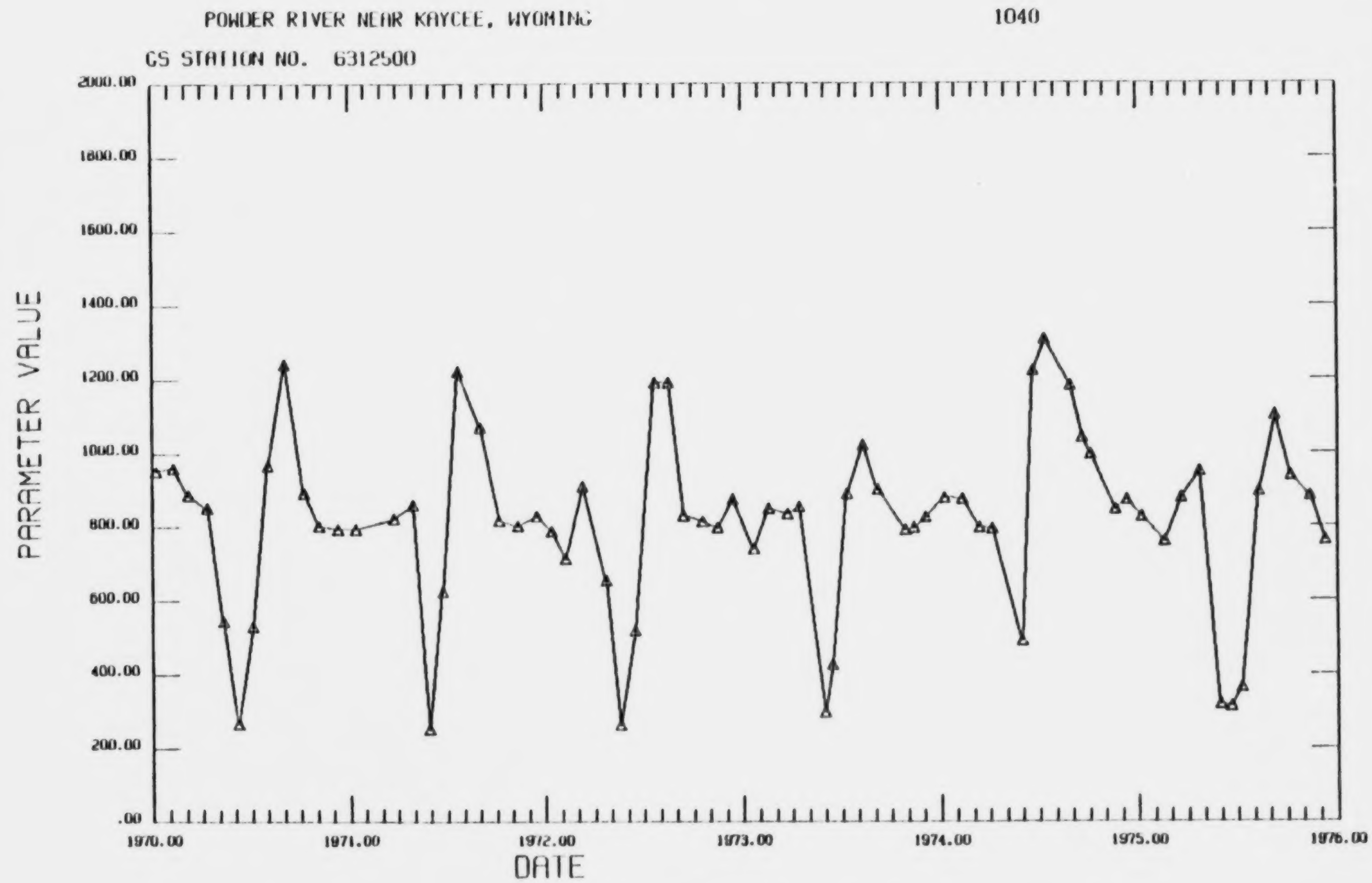


Figure 13. Total Salts: Powder River near Kaycee

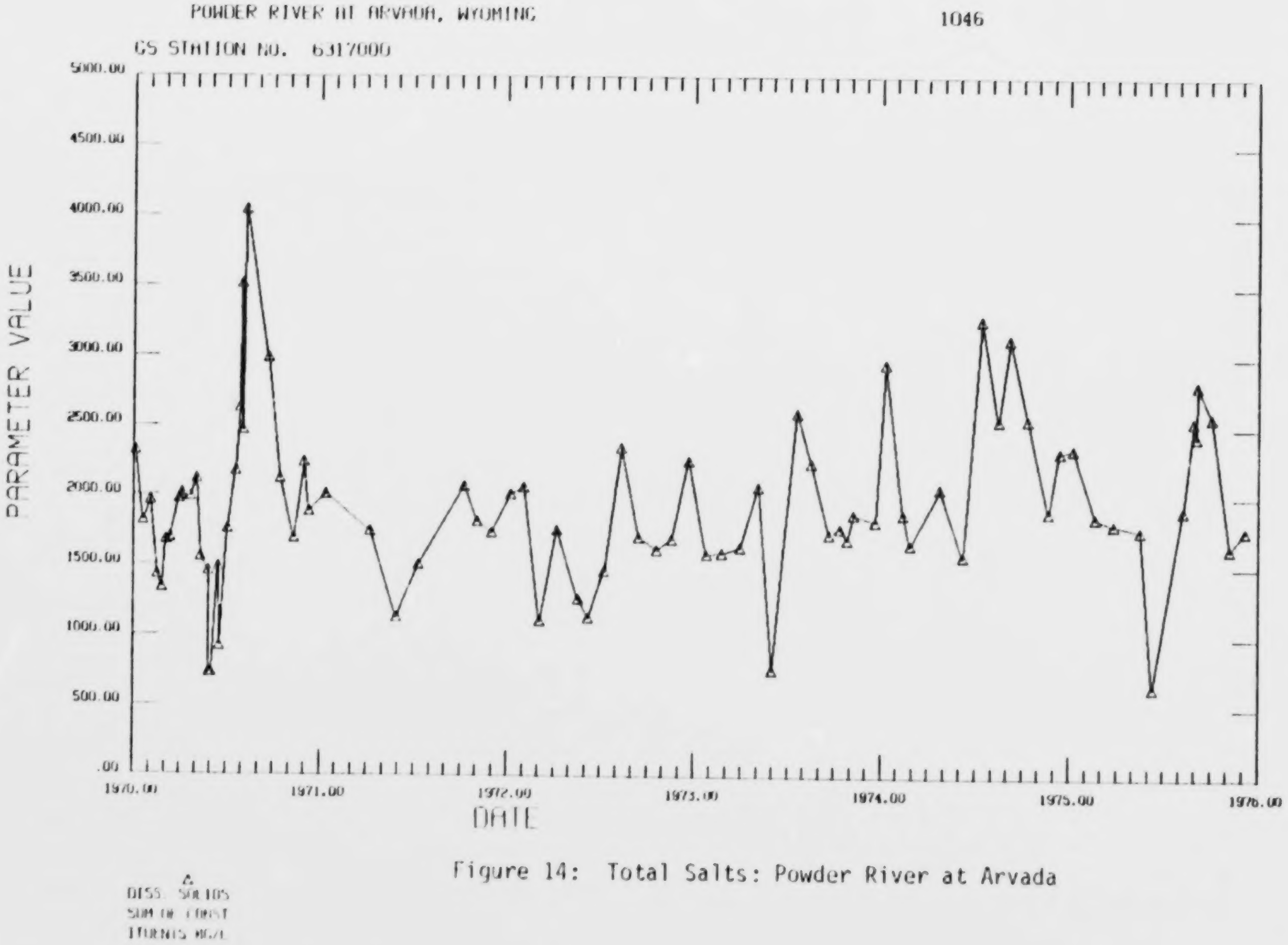


Figure 14: Total Salts: Powder River at Arvada

The salt load contributed by Clear Creek is the second highest among the monitored tributaries. However, it also contributes nearly half of the total flow. The effect of nearly doubling the flow in the river with water containing an average concentration of 697 mg/l. total dissolved solids, the lowest concentration of all tributaries, is to dilute the total dissolved solids concentration in the river. Figure 15 again shows the same relationship between winter peak concentrations and summer peak concentrations that exists in the other portions of the drainage which contain irrigated lands. An increase of about 28 percent is recorded during the summer season. This increase can again be attributed to irrigation return flows and the higher summer evaporation rate.

Between Arvada and Moorhead, Montana, 87 tons of salt per day are contributed by unknown sources. Since there is little irrigation along this section of the river and there are no point source discharges, the contribution can be attributed to natural non-point sources.

Assuming that the percentage increase of total dissolved solids at periods of peak concentration are proportional at all concentration levels during the irrigation season, the contribution from irrigation should equal approximately 25 percent of the total salt load during the months May through September. However, since the increase is only reflected over a five month period and the average daily salt load figures are representative of a 12 month period, the salt load attributable to irrigation on the Powder River equals 25 percent x 5/12 x 1,299 tons/day (at Moorhead, Montana) or 135 tons per day.

Table 23 represents a rough estimation of the salt load allocation for the Powder River Drainage, based on the data developed in this section. These figures are not purported to be a comprehensive analysis of the salinity issue in the Powder River drainage. They do, however, give a general idea of the major sources in the drainage and some estimation of what effect man's activities maintain on salinity levels in the Powder River.

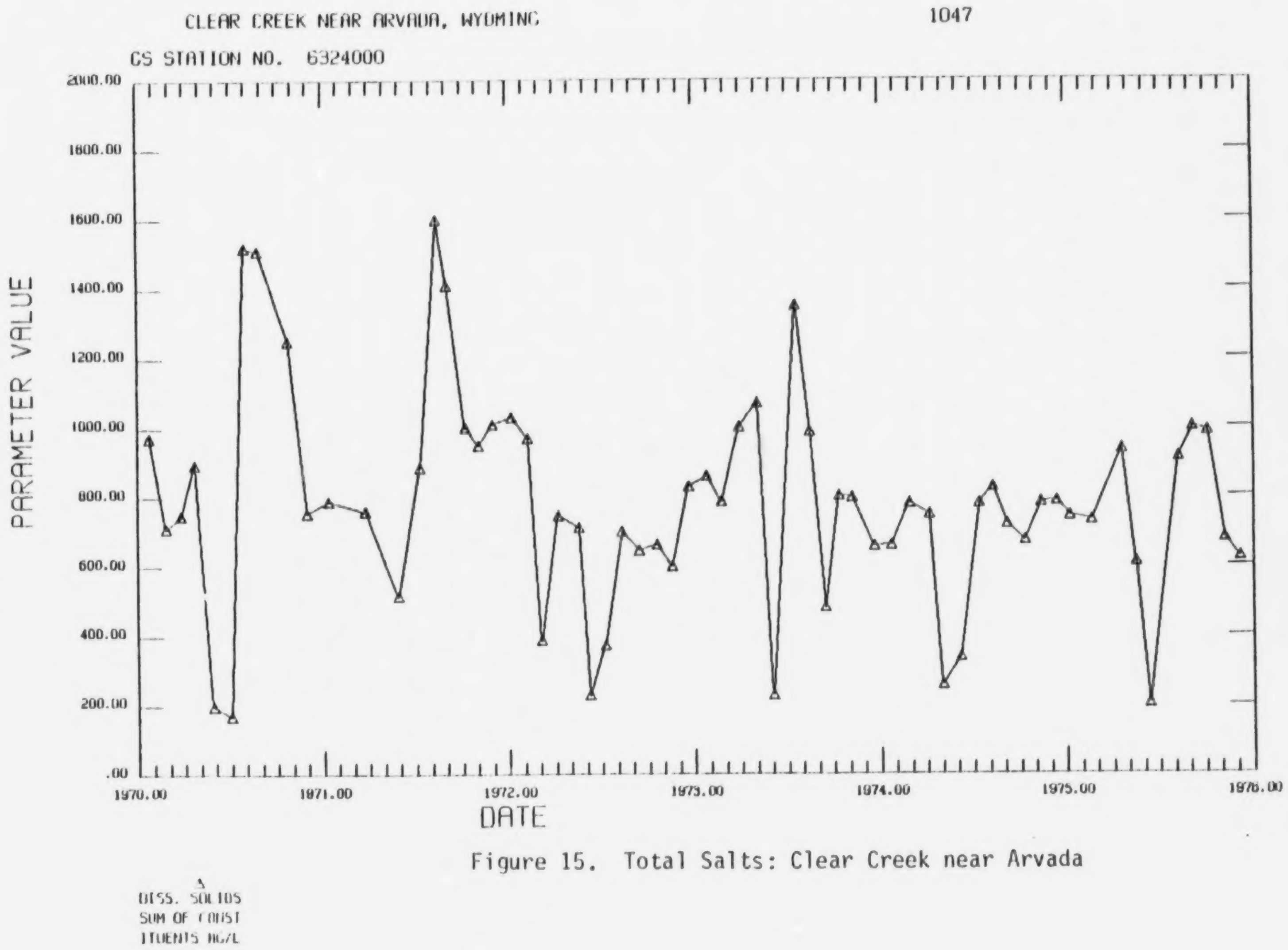


Figure 15. Total Salts: Clear Creek near Arvada

TABLE 23

Major Salt Sources - Powder River

Sources	Load (Tons/Day)	Percent of Total
Natural	807	62.1
Point Sources (Oil Treaters)	357	27.5
Irrigated Agriculture	135	10.4
Totals	1,299	100.0

Source: PRAPO Generated Data.

The estimation of the salt load from irrigated agriculture is believed to be conservative, since no attempt was made to define what portion of the summer increase was related to a higher evaporation rate. Approximately 66,300 acres of land are irrigated in the Powder River Basin. Based on 135 tons of salt per day, the average annual salt yield for these lands would equal 0.74 tons per acre per year. Petroleum production is the activity which has the greatest effect on increasing the natural salinity load in the Powder River. Salt Creek accounts for 26 percent of the total load. However, total dissolved solids concentrations in Salt Creek have shown a decline in the last four years as more oil treater facilities comply with discharge effluent limitations. Natural sources are and will remain the largest contributor to the salt load in the Powder River.

Powder River Summary

The tributaries and the mainstem of the Powder River have the greatest number of water quality excesses in the three county area. In almost all cases, the sources are of natural origin and maintain little effect on the beneficial uses of the waters. The man-made sources pertaining to water quality excesses comes from increased total dissolved solids concentrations and increased organic and bacterial concentrations. Swimmable and fishable criteria are most often violated, yet the very nature of the Powder River creates its own swimming and fishing limitations. Salinity levels in the river below Sussex would probably limit its use for widespread irrigation. However, it is not salinity levels which limit irrigation below Sussex, but rather the topography of the area which would require the water to be pumped rather than gravity fed. The dilution effect of Crazy Woman Creek, and especially Clear Creek, return TDS concentrations in the river to levels where they are once again capable of being used for irrigation as the waters enter Montana. The stricter limitations being placed on point source discharges in Salt Creek and others, as well as the stability of the number of irrigated acres in the drainage limit the possibility of large salt load increases in the Powder River to occur.

Clear Creek

The Clear Creek segment in the Bighorn National Forest includes the North, Middle and South Forks as well as a section of the mainstem below the confluences. Water quality data are very limited. These limited data indicate that the water quality is generally good. Isolated fecal coliform violations were noted and appear to result from various recreational activities. Water quality standard (1974) violations for pH were also observed while criteria excesses consist of insufficient alkalinities during runoff events. Neither of these two observations are indicative of pollution problems in this segment.

Between Forest Service land and Buffalo there are insufficient data to derive a definitive statement about the water quality in the segment. Data collected for PRAPO indicated no water quality standard violations or criteria excesses.

The in-Buffalo segment exhibited pH violations for the 1974 water quality standards and one criteria excess each for boron (agriculture and stock water) and cyanides (aquatic life). These criteria excesses are believed to be from natural sources.

The Buffalo to Texaco Dam segment shows sharp increases in water quality standard violations for fecal coliform and pH determinations, while increases in criteria excesses, ammonia (2) and mercury (1), were also noted. Buffalo's sewage treatment plant appears to be the primary source of problem in this segment.

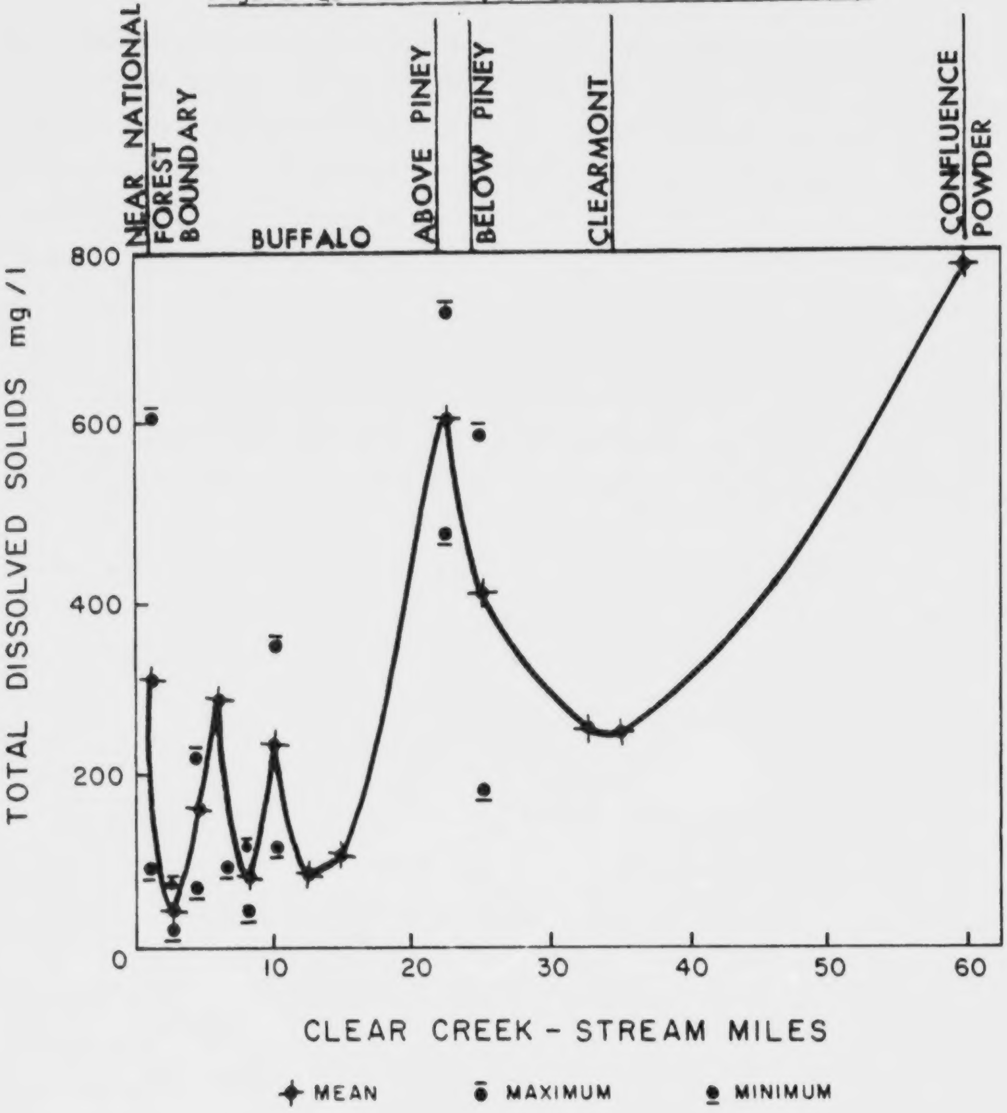
The Texaco Dam to north segment is characterized by an occasional pH and fecal coliform violation and by water quality criteria excesses for aquatic life, agriculture and primary contact recreation. Parameters which were in excess of criteria levels include boron (2), iron (2), mercury (3), and ammonia (4). Natural conditions are believed to be the source of boron, iron and mercury. Ammonia excesses are probably from improperly functioning individual wastewater systems and runoff from livestock grazing areas. None of these criteria excesses have shown to be consistent and are not believed to have caused sustained use impairment. The predominant problem appears to be the sharp increases in salinity in this segment. Based on USGS data obtained near Arvada, the periods of highest constituent concentrations occur in July and August.

Figure 16 presents spatial salinity data collected during the past two years. Downstream concentrative increases are diluted by a series of tributaries from Forest Service land to approximately Clearmont. From Clearmont to the confluence with the Powder River a sharp increase in total dissolved solids was observed. The probable sources for this have been previously discussed in the Powder River Salinity section.

Figure 17 illustrates fecal coliform concentrations from above Buffalo to the confluence with the Powder River. This figure corroborates the previously described data which show excessive coliform concentrations only in the below Buffalo segment.

Piney Creek is a tributary to Clear Creek, contributing nearly fifty percent of the total flow in Clear Creek. Only a few water quality criteria excesses were noted in this drainage, other than the naturally predominant characteristics of low alkalinity and high pH. Natural sources account for criteria excesses of selenium (2) and mercury (1). Two fecal coliform excesses and four ammonia excesses were recorded. These are believed to be caused by individual wastewater systems and livestock and wildlife near the stream. None of these criteria excesses are a constant problem and little if any use impairment is noted.

Figure 16 - Salinity Distribution: Clear Creek

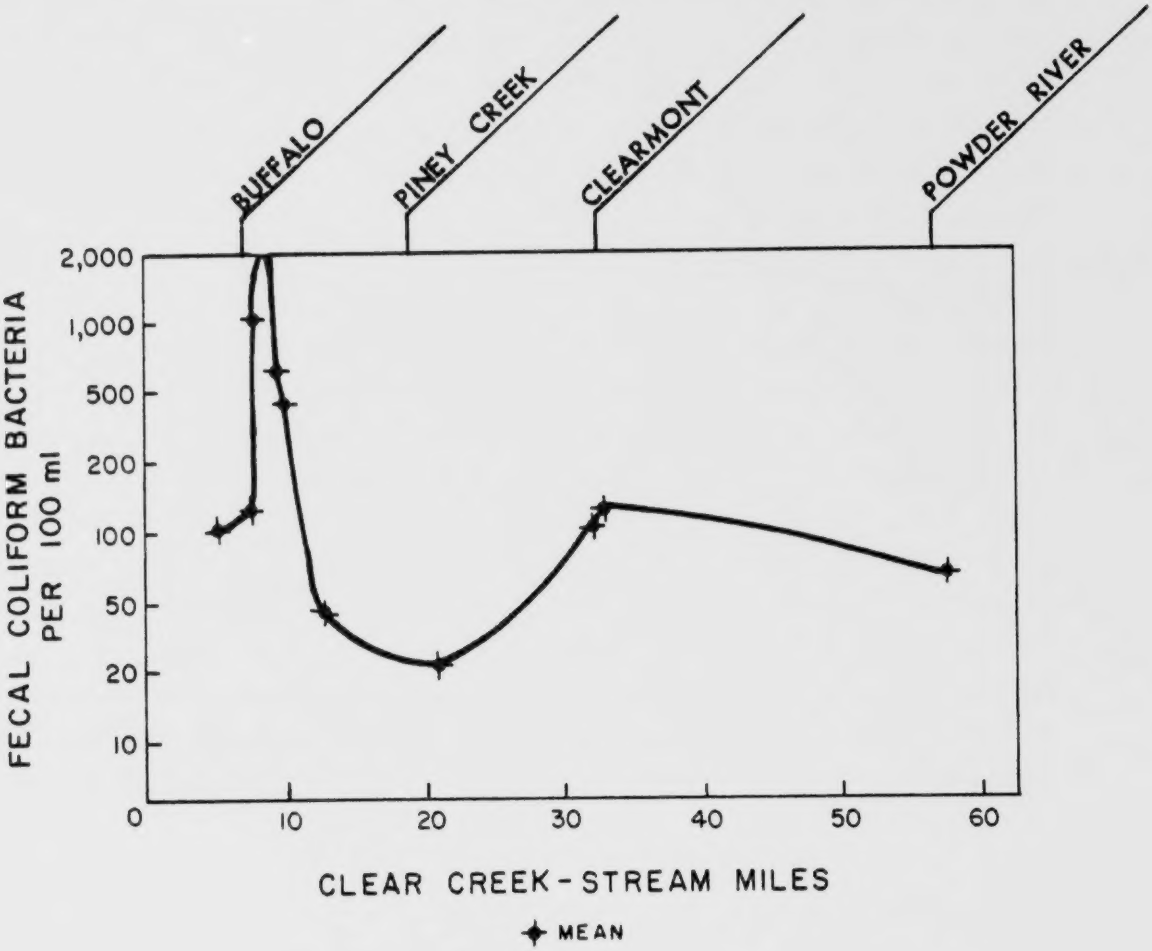


Source: Assessment Report and Recommendations, PRAPO Planning Area, Water Resources Research Institute, p. 38.

Clear Creek Summary

At the present time, the greatest water quality problems in Clear Creek occur in the segment between Buffalo and the Texaco Dam. Buffalo's wastewater treatment facility is the major source of these problems. The proposed upgrading of the facility should eliminate most of the problems, however there may be a need for advanced treatment to eliminate toxicity problems from ammonia and

Figure 17 - Fecal Coliform Distribution: Clear Creek



Source: Assessment Report and Recommendations, PRAPO Planning Area, Water Resources Research Institute, p. 39.

chlorine. Whether this in fact will be necessary has yet to be determined. Use impairment for aquatic life and primary contact recreation at present do exist in portions of this segment, primarily below the municipal wastewater discharge.

On occasion salinity concentrations in Clear Creek may peak at levels which if maintained could pose a potential problem to irrigation. However, the present mean concentration in Clear Creek is well below that point and has shown no prolonged tendency to increase. In fact, TDS concentrations since 1974 have been well below those in the first part of the decade.

Area ranchers and conservation personnel have noted that since the completion of Healy Reservoir on Clear Creek at the point of Texaco's diversion to Lake DeSmet, the groundwater levels along Clear Creek appear to be higher. These high groundwater levels are leaching salts from the soils and depositing them on the surface in draws and gulleys. This potential problem should be carefully monitored on Clear Creek and on Piney Creek as Texaco begins to raise the level of Lake DeSmet.

Donkey Creek

Donkey Creek in Campbell County drains an area which includes most of the City of Gillette. Point source discharges into the drainage include the Gillette wastewater treatment facility, Wyodak Mine and Neil Simpson Power Plant. The stream in this area is a Class III stream but is upgraded to a Class II stream near the county line. Criteria for aquatic life, stock watering, agriculture, and primary contact recreation are in excess in this stream, however, in most cases, they include only a single excess. Iron, mercury, pH, fluoride and boron fall into this category. Excesses of criteria levels for dissolved oxygen (7), fecal coliform bacteria (9), and ammonia (6) are greatest problems in the drainage. All of these can be traced to the inability of Gillette's sewage treatment facility to adequately treat the wastewaters generated by the greatly expanded population of Gillette.

Little Powder River

The Little Powder River drains most of the northern portions of Campbell County including the northern edges of the City of Gillette. The waters of this river contain numerous excesses of various criteria for aquatic life, stock water, agriculture and primary contact recreation. Natural deposits of iron create the largest problem with this drainage, having a total of eighteen excesses in the period of record. Other parameters whose sources are generally of natural origin include fluoride (1), mercury (2), pH (4), boron (5), lead (4) and chlorides (2). Man-related excesses include fecal coliform bacteria (2), and ammonia (7). Sources of these violations are probably livestock grazing near the stream. Dissolved oxygen levels have been reported below criteria and standards levels; climate and the stream morphology are the causes of these violations. Total dissolved solids levels in the drainage are very high due to the generally saline geology underlying the area and the fact that approximately 25 percent of the alluvial soils in the drainage are alkaline or saline.

The average number of irrigated acres in the drainage is less than 2,500. This low number of acres has little effect on the water quality.

Point source discharge permits in the drainage number ten, four oil well treaters, two mine discharges and four domestic discharges. Of these, only six are actively discharging at a total flow of less than 1 cubic foot per second.

Groundwater Quality

Groundwater information is limited for the three-county area. Water quality data are even more limited. Data were basically obtained from studies concerning mining operations, two groundwater studies undertaken by the Water Resources Research Institute in the South Sheridan area, the unincorporated community of Story, and the United States Geological Survey. Table 24 contains data compiled from a variety of groundwater sources in the Powder River Basin. These wells, when sampled, were not affected by ongoing mining activities. These data show the range of concentrations observed in soluble salts concentrations. As observed, there is much variation in the naturally occurring groundwater quality of the Powder River Basin.

TABLE 24

Area Groundwater Quality: Mined Lands Areas

Aquifer	TDS (mg/1.)	pH	Iron (mg/1.)	Sodium (mg/1.)	Sulfate mg/1.)	SAR
Overburden	4800	7.1	0.02	1355	1320	51.3
Coal Cutout	5800	7.2	0.30	720	3120	4.7
Coal	520	7.4	0.40	135	182	4.7
Coal	1600	8.4	0.10	430	4.0	50.7

Source: Water Quality Determinations, Mined Lands Areas, Northeastern Wyoming, Water Resources Research Institute, p. 23.

Table 25 was prepared from different sources and presents discharge data collected from active mines including the Belle Ayr Mine in Campbell County, the Ash Creek and Big Horn Mines in Sheridan County, and the Decker Mine in Montana. These data are taken to be respresentative of the regional water quality information currently available. These mines have not been very successful in meeting the NPDES discharge requirement of 30 mg/1. for the total suspended solids. The values listed for the first Belle Ayr Mine sample result from coal fines present in mist waters utilized to keep the coal moist in loadout facilities. This water source, though low in volume (1.0 cfs), provided special treatment problems according to recent information. Installation of a sand filter has apparently rectified the problem.

TABLE 25

Water Quality Data: NPDES Sites, PRAPO Planning Area

Site	Sample	TDS (mg/1.)	pH	Iron (mg/1.)	TSS (mg/1.)	Sulfate (mg/1.)
Decker Mine	1	2343	8.5	0.26	---	550
	2	1689	8.9	0.11	---	362
Belle Ayr Mine	1	804	8.5	0.36	300	380
	2	866	8.4	0.54	76	200
Big Horn Mine	1	2987	8.0	0.64	25	---
	2	2750	9.0	0.49	64	---
Ash Creek Mine	1	340	8.3	0.80	140	57

Source: Water Quality Determination, Mined Lands Areas, Northeastern Wyoming, Water Resources Research Institute, p. 31.

Alteration of groundwater quality in affected aquifers has not accompanied mining at AMAX Coal Company's Belle Ayr Mine in Campbell County based on long term monitoring data for these wells. Proper continuous sampling techniques will provide reliable information for analysis purposes at all mine sites in the three-county area.

Data are scarce pertaining to water quality in reclaimed pit areas in Wyoming. Table 26 presents data collected at two abandoned mine sites in Sheridan County.

Statistical comparisons between the concentrations observed in these abandoned spoils and nearby unaffected groundwaters indicate that 5 of 18 analyses revealed statistically significant concentration increases in waters associated with abandoned spoils. Similar tests comparing the spoil waters with nearby surface sources showed that higher concentrations were observed in 6 of 15 spoil samples. In a control test 3 of 15 determinations revealed significant differences when sufface and unaffected groundwaters were compared. The parameters differing in concentration for the first series of analyses were: TDS, hardness, calcium, magnesium, and sulfate while TDS, hardness, pH, calcium, sulfate and nitrate differed in the second test. For the unaffected sources there were differences in pH, calcium and silica (SiO_2). Accompanying analyses for trace metals revealed only cadmium concentrations in excess of drinking water criteria. It should be mentioned that these mines were abandoned over twenty years ago. Modern reclamation methods should produce more environmentally acceptable results.

TABLE 26

Water Quality Data: Reclaimed Pit Areas

Site	Sample	TDS (mg/1.)	pH	TSS (mg/1.)	Iron (mg/1.)	Total Hardness (mg/1.)
Hidden Waters Mine	1	5210	5.8	21	3134	3392
	2	5906	5.9	30	3133	3434
Plachek Spoils	1	2548	8.6	30	1020	1647
Big Horn Mine	2	2372	8.7	26	1262	1221

Source: Water Quality Determination, Mined Lands Areas, Northeastern Wyoming, Water Resources Research Institute, p. 37

Two special groundwater studies were initiated in the South Sheridan and Story areas. These areas were chosen for investigation because they utilize individual drinking water wells and septic systems. Wells are often constructed to the depth of septic tank installations.

No confirmed water-borne diseases have been reported at either location, but considerable population growth is predicted for both areas. Table 27 presents data collected during this investigation. Only one well showed an elevated fecal coliform concentration; a second sample of this site was within normal limits.

At other sampled wells, total bacterial counts or nitrates appeared questionable. In-depth bacteriological testing at these locations could reveal no strictly pathogenic organisms in the isolates evaluated. Several common bacterial forms were found which could cause discomfort to susceptible individuals.

TABLE 27

Groundwater Quality Investigation Story and South Sheridan, Wyoming

Location	No. of Samples	Fecal Coliform (/100 ml)	Fecal Streptococci (/100 ml)	Coliform (/100 ml)	Total Count PCA (35C) (/ml)	Nitrate (mg/l)	TDS (mg/l)
Story	81	0-1	0-7	0-13	0-8000	0-3.9	34-336
South Sheridan	11	0-133	0-298	0-920	11-2360	0-7.6	58-801

Source: Assessment Report and Recommendations, PRAPO Planning Area, Water Resource Research Institute p. 52

Summary of Major Water Quality Problems

The most pressing water quality problems appear to be as follows in the three-county area:

1. In relation to point source pollution, it appears that dissolved oxygen concentrations will probably be maintained at acceptable levels by applying 1977 standards. However, the recommended sewage treatment alternatives for Buffalo and Sheridan, as they now stand, will probably be incapable of reducing ammonia concentrations below non-toxic levels in Clear Creek and Goose Creek. The two cities, the Environmental Protection Agency, the Wyoming Department of Environmental Quality and the project consultants are now working to develop a solution to these problems.

2. Potential salinity problems exist in Prairie Dog Creek, the Middle and North Forks of Powder River, Crazy Woman Creek and Clear Creek if TDS levels in these drainages were to record any consistent sharp increases. Little Powder River, Salt Creek, South Fork of Powder River and Mainstem of Powder River between Sussex and Arvada all have TDS levels which would impair irrigated agriculture in those drainages; however, very little irrigated agriculture occurs in those drainage areas.

3. In relationship to forested lands, it appears that potentially the greatest water quality problems will be from erosion, activities on forest land, and potential water quality degradation from increased recreational use in forested areas. Water quality degradation may also occur from over-grazing and timbering.

4. Due to an increase in residential growth in unincorporated areas and unincorporated communities, many problems have occurred from contaminants leaching out of septic tank systems. In the future, ineffective septic systems may lead to greater contamination of surface waters as well as groundwater quality in various development areas.

5. With increased mining in the three-county area, there will be greater potential for water quality degradation occurring from mining operations. Water quality problems will occur from sedimentation, disturbance of aquifers, and the introduction of saline or toxic materials into the aquifers.

STREAM SEGMENT ANALYSIS AND RECOMMENDED WATER QUALITY STANDARDS

Surface Water Quality Summary

In general, the surface water quality in the PRAPO study area is good. Waters in and around the mountains are excellent. As water flows into the plains areas, the quality deteriorates. Natural conditions contribute a great deal to this trend. Such factors as climate, geology, soils, and topography all influence the natural quality of the water. Man's influence also plays a key part in the determination of water quality in the basin, especially those waters which are located close to populated areas.

In reviewing stream segments for their ability to meet the 1983 fishable-swimmable criteria, it was necessary to consider all stream segments, whether or not they were able to hydraulically support those uses.

The following stream segments will be unable to meet 1983 fishable-swimmable criteria because of natural sources of pollution:

Little Powder River
Mainstem Powder River near Arvada
South Fork Powder River

Trace metals in the Little Powder River, Mainstem Powder River and South Fork Powder River, as well as periodically low dissolved oxygen levels in the mainstem Powder River, will prevent these stream segments from meeting the 1983 goals.

The following stream segments will be unable to meet 1983 fishable-swimmable criteria, unless action is taken to eliminate man-caused sources of pollution:

Goose Creek below Sheridan
Clear Creek below Buffalo
Stonepile-Donkey Creek below Gillette

These segments will not presently meet the 1983 goals because of excessive levels of ammonia and fecal coliform bacteria. Upgrading of sewage treatment facilities in Sheridan, Buffalo and Gillette is required to eliminate these sources of pollution.

Little Goose Creek below its confluence with McCormick Creek and Big Goose Creek from above Sheridan to its confluence with Little Goose Creek have also recorded high numbers of coliform bacteria. Not enough data has been collected in these segments, however, to determine whether they are unable to meet the 1983 criteria at this time.

A basic problem with the coliform data collected in this program, as well as the coliform data reported by USGS, is that the frequency of collection was at best one sample per month. Both the Federal water quality criteria and the Wyoming water quality standards for fecal coliform bacteria are based on a logarithmic mean of not less than five samples in a 30-day period. Therefore, any reference to coliform excesses in this plan must be conditioned - that they are based on instantaneous samples and do not conform to standard monitoring procedures. Because of the very high coliform numbers in the creeks below the sewage outfalls at Sheridan, Buffalo and Gillette and because effluent sampling at those sewage treatment plants does follow standard procedure, those three stream segments are the only ones which can be readily identified as not presently meeting the 1983 swimmable goal.

Table 28 summarizes the water quality information discussed previously in this chapter.

Point Source Review

The Water Resources Research Institute undertook this work effort in two phases. The first contained an assessment of the municipal point source pollution problems associated with the sewage treatment plants in Sheridan, Buffalo and Gillette. This consisted of applying mathematical models to determine present and future water quality conditions associated with sewage discharge from the three cities. The second work item was a review of the NPDES program in the three-county area.

TABLE 28

WATER QUALITY SUMMARY: PRAPO PLANNING AREA

Stream Segment	Season W-Wet D-Dry	Water Quality Excess & Number		Type	Source	Impaired Use	Recommended Control Action	Remarks
Tongue River (Source to Dayton)	W	Lead	(2)	EPA	Natural	Raw Water	None	A total of 17 excesses were noted; of these only pH violated Wyoming water quality standards. Source of ammonia excess was probably wildlife or livestock. Because of season, wildlife was probable cause of fecals excess.
	D	"	(3)	"	"	"	"	
	W	pH	(2)	WWQS	"	Aquatic Life	"	
	D	"	(2)	"	"	"		
	W	Mercury	(1)	EPA	"	"	"	
	D	"	(1)	"	"	"	"	
	W	Alkalinity	(1)	"	"	"	"	
	W	Iron	(1)	"	"	Raw Water	"	
	D	"	(1)	"	"	"	"	
	W	Manganese	(1)	"	"	Aquatic Life	"	
	W	Ammonia	(1)	"	Natural or Agriculture	"	"	
	D	Fecal Coliform	(1)	"	Natural	Primary Contact	"	
Tongue River (Dayton to Monarch)	W	pH	(2)	WWQS	"	Aquatic Life	"	A total of 17 excesses were noted. Again, pH was the only WWQS violation. Total suspended solids levels rose sharply during early spring, possibly due to flushing of stream channel.
	W	Ammonia	(2)	EPA	Municipal or Agriculture	"	Upgrade Ranchester Sewage Treatment Plant	
	D	"	(1)	"	"	"	"	
	D	Fecal Coliform	(1)	"	"	Primary Contact	None	
	W	Iron	(2)	"	Natural	Raw Water	"	
	W	Lead	(2)	"	"	"	"	
	D	"	(3)	"	"	"	"	
	W	Manganese	(1)	"	"	"	"	
	W	Chromium	(1)	"	"	"	"	
	W	Silver	(1)	"	"	"	"	
	W	Mercury	(1)	"	"	Aquatic Life	"	
	D	"	(1)	"	"	"	"	
Tongue River (Monarch to Goose Creek)	W	pH	(1)	WWQS	"	"	"	This short section has only 5 excesses. Fecal excess is probably from winter grazing activities.
	D	"	(1)	"	"	"	"	
	W	Mercury	(2)	EPA	"	"	"	
	D	Fecal Coliform	(1)	"	Agriculture	Primary Contact	"	

Stream Segment	Season W-Wet D-Dry	Water Quality Excess & Number	Type	Source	Impaired Use	Recommended Control Action	Remarks
Tongue River (Goose Creek to State line)	W	pH (2)	WWQS	Natural	Aquatic Life	None	A total of 21 excesses in this segment. Four of the fecal coliform excesses were above water quality standard.
	D	" (1)	"	"	"	"	
	W	Mercury (2)	EPA	"	"	"	
	D	" (1)	"	"	"	"	
	W	Ammonia (3)	"	Municipal & Domestic	"	Upgrade Sheridan Sewage Treatment Plant	
	D	" (3)	"	"	"	"	
	W	Fecal Coliform (6)	EPA & WWQS	"	Primary Contact	"	
	D	" (5)	"	"	"	"	
North Fork Powder River		No Excesses					
Middle Fork Powder River	W	pH (4)	"	Natural	Aquatic Life	None	
South Fork Powder River	W	Fecal Coliform (2)	EPA	Natural & Agriculture	Primary Contact	"	A total of 14 excesses are recorded. Wildlife and livestock are probable sources of high coliform counts.
	D	" (1)	WWQS	"	"	"	
	D	Ammonia (1)	EPA	"	Aquatic Life	"	
	W	Iron (1)	"	Natural	"	"	
	D	" (2)	"	"	"	"	
	W	Mercury (1)	"	"	"	"	
	D	" (1)	"	"	"	"	
	D	Chromium (1)					
	D	Aluminum (1)	"	"	"	"	
	D	Arsenic (1)	"	"	"	"	
	D	Cadmium (1)	"	"	"	"	
	D	Lead (1)	"	"	"	"	
Powder River (Kaycee to Sussex)	W	Fecal Coliform (4)	"	Municipal	Primary Contact	Upgrade Kaycee Sewage Treatment Plant	A total of 9 excesses were recorded.
	D	" (1)	"	"	"	"	
	W	Ammonia (1)	"	"	Aquatic Life	"	
	W	Iron (2)	"	Natural	"	None	
	W	Boron (1)	"	"	"	"	

Stream Segment	Season W-Wet D-Dry	Water Quality Excess & Number		Type	Source	Impaired Use	Recommended Control Action	Remarks
Powder River (Sussex to Montana)	D	pH	(2)	WWQS	Natural	Aquatic Life	None	A total of 58 excesses were recorded for this stream segment. High ammonia and fecal coliform concentrations are related to livestock and wildlife grazing and septic system discharges. High TDS concentrations are also present in this segment due to natural sources, point sources and irrigation.
	W	Fecal Coliform	(8)	EPA & WWQS	Natural, Domestic & Agriculture	Primary Contact	Septic System Program, Agriculture NPS Control Program	
	D	"	(5)	"	"	"	"	
	W	Ammonia	(6)	EPA	"	Aquatic Life	"	
	D	"	(4)	"	"	"	"	
	W	Dissolved Oxygen	(1)	EPA & WWQS	Natural	"	None	
	D	"	(4)	"	"	"	"	
	W	Mercury	(4)	EPA	"	"	"	
	D	"	(2)	"	"	"	"	
	W	Iron	(1)	"	"	"	"	
	D	"	(2)	"	"	"	"	
	D	Cyanide	(1)	"	"	"	"	
	W	Chromium	(2)	"	"	"	"	
	W	Boron	(2)	"	"	Irrigation	"	
	W	Cadmium	(2)	"	"	"	"	
	W	Manganese	(1)	"	"	"	"	
	W	Arsenic	(1)	"	"	Irrigation & Stockwater	"	
	D	Aluminum	(2)	"	"	Stockwater	"	
	W	Fluoride	(1)	"	"	"	"	
	W	Lead	(2)	"	"	"	"	
	W	Radium 226	(1)	WWQS	"	Raw Water	"	
	D	"	(1)	"	"	"	"	
Big Goose Creek (East Fork)	W	Alkalinity	(2)	EPA	Natural	Aquatic Life	"	
	D	"	(1)	"	"	"	"	
Big Goose Creek (West Fork)	W	Alkalinity	(2)	"	"	"	"	
	D	"	(2)	"	"	"	"	
	W	pH	(1)	WWQS	"	"	"	

Stream Segment	Season W-Wet D-Dry	Water Quality Excess & Number		Type	Source	Impaired Use	Recommended Control Action	Remarks
Big Goose Creek (Fork Confluence to Water Supply Inlet)	W	Alkalinity	(2)	EPA	Natural	Aquatic Life	None	
	W	pH	(1)	WWQS	"	"	"	
	D	"	(1)	"	"	"	"	
Big Goose Creek (Inlet to above Town)	W	pH	(1)	"	"	"	"	
	W	Fecal Coliform	(1)	EPA	Agriculture	Primary Contact	"	
Big Goose Creek (Above Town to Sewage Outfall)	W	pH	(3)	WWQS	Natural	Aquatic Life	"	High fecal coliform counts caused by illegal discharges from septic systems is the most pressing problem in this segment.
	D	"	(1)	"	"	"	"	
	W	Fecal Coliform	(7)	EPA & WWQS	Domestic Sewage	Primary Contact	Enforcement of Adequate On-Site Disposal System Program	
	D	"	(1)	"	"	"	"	
	W	Ammonia	(1)	EPA	"	Aquatic Life	"	
	D	Boron	(1)	"	Natural	Irrigation	None	
Goose Creek (Sewage Outfall to Plachek Pit)	W	pH	(1)	WWQS	"	Aquatic Life	"	Sheridan's Sewage Treatment Plant is worst source of pollution in segment. Treatment greater than secondary may be needed to correct ammonia toxicity problems.
	D	"	(2)	"	"	"	"	
	W	Fecal Coliform	(4)	EPA & WWQS	Municipal	Primary Contact	Upgrade Sheridan Sewage Treatment Plant	
	D	"	(8)	"	"	"	"	
	W	Ammonia	(5)	EPA	"	Aquatic Life	"	
	D	"	(4)	"	"	"	"	
	W	Mercury	(3)	"	Natural	"	None	
	W	Iron	(1)	"	"	"	"	
	D	Aluminum	(1)	"	"	Stockwater	"	
Goose Creek (Plachek Pit to Confluence)	D	pH	(2)	WWQS	Natural	Aquatic Life	"	
	W	Fecal Coliform	(4)	EPA & WWQS	Municipal	Primary Contact	Upgrade Sheridan Sewage Treatment Plant	
	D	"	(2)	"	"	"	"	

Stream Segment	Season W-Wet D-Dry	Water Quality Excess & Number	Type	Source	Impaired Use	Recommended Control Action	Remarks
Little Goose Creek	W	Alkalinity (5)	EPA	Natural	Aquatic Life	None	Illegal septic system discharges are the critical problem in this drainage.
	D	" (3)	"	"	"	"	
	W	pH (6)	WWQS	"	"	"	
	W	Dissolved Oxygen (1)	EPA & WWQS	"	"	"	
	W	Fecal Coliform (5)	EPA	Domestic	Primary Contact	Enforcement of Septic System Program	
	D	" (2)	"	"	"	"	
Prairie Dog Creek	W	Iron (1)	"	Natural	Aquatic Life	None	
Clear Creek (In forest)	W	Alkalinity (8)	"	"	"	"	
	W	pH (3)	WWQS	"	"	"	
	D	" (2)	"	"	"	"	
	W	Fecal Coliform (1)	EPA	Recreation	Primary Contact	"	
Clear Creek (Above Buffalo)		No Excesses					
Clear Creek (In Buffalo)	D	pH (1)	WWQS	Natural	Aquatic Life	"	
	D	Cyanide (1)	EPA	"	"	"	
	D	Boron (1)	"	"	Stockwater	"	
Clear Creek (Below Buffalo to Texaco Dam)	W	pH (4)	WWQS	Municipal	Aquatic Life	Upgrade Buffalo Sewage Treatment Plant	A new sewage treatment facility will correct most of the problems in this segment. May need treatment higher than secondary to eliminate ammonia toxicity.
	D	" (5)	"	"	"	"	
	W	Fecal Coliform (7)	EPA & WWQS	"	Primary Contact	"	
	D	" (3)	"	"	"	"	
	W	Ammonia (1)	EPA	"	Aquatic Life	"	
	D	" (1)	"	"	"	"	
	D	Mercury (1)	"	Natural	"	None	

Stream Segment	Season W-Wet D-Dry	Water Quality Excess & Number	Type	Source	Impaired Use	Recommended Control Action	Remarks
Clear Creek (Texaco Dam to Confluence)	D	pH (1)	WWQS	Natural	Aquatic Life	None	Domestic sewage or livestock grazing may cause ammonia excesses but there are too few over a full 8 year period to warrent action.
	W	Fecal Coliform (1)	EPA	Agriculture	Primary Contact	"	
	W	Ammonia (2)	"	Agriculture or Domestic	Aquatic Life	"	
	D	" (2)	"	"	"	"	
	W	Boron (2)	"	Natural	Irrigation	"	
	W	Iron (2)	"	"	Aquatic Life	"	
	W	Mercury (2)	"	"	"	"	
	D	" (1)	"	"	"	"	
Crazy Woman Creek	W	Alkalinity (11)	"	"	"	"	
	W	Iron (1)	"	"	"	"	
Piney Creek	W	Alkalinity (9)	"	"	"	"	
	D	" (3)	"	"	"	"	
	W	pH (5)	WWQS	"	"	"	
	W	Ammonia (2)	EPA	Agriculture	"	"	
	D	" (2)	"	"	"	"	
	W	Fecal Coliform (1)	"	"	Primary Contact	"	
	D	" (1)	"	"	"	"	
	W	Mercury (1)	"	Natural	Aquatic Life	"	
	W	Selenium (2)	"	"	Irrigation	"	
Salt Creek	W	Dissolved Solids (4)	"	Petroleum Production	Stockwater	Strict Enforcement of Effluent Limitations	Salt Creek has a great influence on Salt Load in the Powder River. It is a Class III stream, will not support aquatic life.
	D	" (2)	"	"	"	"	
	W	Chlorides (8)	"	"	"	"	
	D	" (7)	"	"	"	"	
	W	Fluorides (7)	"	"	"	"	
	D	" (7)	"	"	"	"	
	W	SAR (5)	"	"	Irrigation	"	
	D	" (4)	"	"	"	"	

Stream Segment	Season W-Wet D-Dry	Water Quality Excess & Number	Type	Source	Impaired Use	Recommended Control Action	Remarks
Salt Creek (cont'd)	W	Boron (6)	EPA	Petroleum Production	Irrigation	Strict Enforcement of Effluent Limitations	
	W	Iron (1)	"	"	Aquatic Life	"	
	D	" (2)	"	"	"	"	
	D	pH (1)	WWQS	"	"	"	
	W	Ammonia (1)	EPA	Agriculture	"	None	
	D	" (2)	"	"	"	"	
	D	Dissolved Oxygen (1)	"	Natural	"	"	
Youngs Creek	W	pH (2)	WWQS	"	"	"	
	W	Iron (1)	EPA	"	"	"	
Donkey Creek	W	Dissolved Oxygen (3)	"	Municipal	"	Upgrade Gillette Sewage Treatment Plant	Gillette's Sewage Treatment Plant contributes most of the problems. Stream is Class III and will not support aquatic life.
	D	" (4)	"	"	"	"	
	W	Fecal Coliform (5)	EPA & WWQS	"	Primary Contact	"	
	D	" (4)	"	"	"	"	
	W	Ammonia (3)	EPA	"	Aquatic Life	"	
	D	" (3)	"	"	"	"	
	W	Iron (1)	"	Natural	"	None	
	W	Mercury (1)	"	"	"	"	
	W	pH (1)	WWQS	"	"	"	
	D	Fluorides (1)	EPA	"	Stockwater	"	
	W	Boron (1)	"	"	Irrigation	"	
Little Powder River	W	pH (4)	WWQS	"	Aquatic Life	"	
	W	Fecal Coliform (1)	EPA	Agriculture	Primary Contact	"	
	W	Ammonia (3)	"	"	Aquatic Life	Agriculture NPS Control Program	
	D	" (4)	"	"	"	"	

Stream Segment	Season W-Wet D-Dry	Water Quality Excess & Number		Type	Source	Impaired Use	Recommended Control Action	Remarks
Little Powder River (cont'd)	W	Dissolved Oxygen	(1)	WWQS & EPA	Natural	Aquatic Life	None	
	D	"	(1)	"	"	"	"	
	W	Iron	(15)	"	"	"	"	
	D	"	(3)	"	"	"	"	
	W	Mercury	(2)	"	"	"	"	
	W	Boron	(5)	"	"	Irrigation	"	
	D	Chlorides	(2)	"	"	Stockwater	"	
	W	Fluorides	(1)	"	"	"	"	
	W	Lead	(2)	"	"	"	"	
	D	"	(2)	"	"	"	"	

Stream Segment: Describes reach of stream; see Map 12 for corresponding listing of segments.

Season: Wet season = March 1 through September 30; Dry season = October 1 through March 1. These seasons were determined after inspecting USGS flow records for the PRAPO planning area.

Water Quality Excess and Number: The particular parameter observed in excess of either published Environmental Protection Agency criteria (Quality Criteria for Water, 1976 or Water Quality Criteria, 1972), or the Wyoming Water Quality Standards(1974) is identified. Also, the number of excess samples observed are given.

Type: Identifies whether the parametric excess exceeds the abovementioned EPA criteria or Wyoming Standards.

Impaired Use: Identifies the instream use which is impaired corresponding to the parameter mentioned under Water Quality Excess. Use impairment is listed in the table when the water quality criteria is exceeded for any one of the stream uses identified in Table 10 or when the criteri for aquatic life or primary recreation is exceeded.

Recommended Control Action: For those instream excesses which are not caused by natural sources and do demonstrate a persistent tendency of exceeding the criteria, the control action as articulated in the text is identified. Not all control actions discussed in the text are included in this table since the purpose of some of the control programs is to prevent water quality problems where excesses are not currently being observed.

Remarks: Self explanatory.

Source: Assessment Report and Recommendations, PRAPO Planning Area, Water Resources Research Institute, p. 41 - 42 and PRAPO Staff.

TABLE 29

Present and Expected Waste Loads: Goose Creek, Sheridan County

Facility Plan Design Population for 1995 26,325

Year	Population	Waste Loads Flow (cfs)	 CBOD (mg/l)	Comments
1976	13,200	3.1	96	Present conditions
1982	16,000	3.7	96	Average expected value
	19,200	4.5	96	Average expected value
	19,800	4.5	96	Average expected value
	16,000	3.7	115	No additional treatment
	19,200	4.5	115	No additional treatment
	19,800	4.5	115	No additional treatment
	16,000	3.7	15	95/20 reduction
	19,200	4.5	15	95/20 reduction
	19,800	4.5	15	95/20 reduction
	16,000	3.7	15	95/95 reduction
	19,200	4.5	15	95/95 reduction
	19,800	4.5	15	95/95 reduction
	16,000	3.7	45	NPDES standard
	19,200	4.5	45	NPDES standard
	19,800	4.5	45	NPDES standard
1995	25,000	5.8	96	Average expected value
	31,700	7.5	96	Average expected value
	33,300	7.5	96	Average expected value
	25,000	5.8	115	No additional treatment
	31,700	7.5	115	No additional treatment
	33,300	7.5	115	No additional treatment
	25,000	5.8	15	95/20 reduction
	31,700	7.5	15	95/20 reduction
	33,300	7.5	15	95/20 reduction
	25,000	5.8	15	95/95 reduction
	31,700	7.5	15	95/95 reduction
	33,300	7.5	15	95/95 reduction
	25,000	5.8	45	NPDES standard
	31,700	7.5	45	NPDES standard
	33,300	7.5	45	NPDES standard

Source: Assessment Report and Recommendations, PRAPO Planning Area, Water Resources Research Institute, p. 45.

TABLE 30

Goose Creek Dissolved Oxygen Response

Year	Ultimate Waste Loads CBOD (mg/1)	Ultimate Waste Loads NBOD (mg/1)	Maximum DO Deficit (mg/1)	DO Level at Maximum Deficit (mg/1)	Comments
1982	96	33	5.3	3.2	Average effluent
	115	41	5.4	31	Surveyed effluent
	45	12	3.7	4.8	NPDES effluent
	45	0.75	3.7	4.8	NPDES effluent[b]
	15	12	5.0	3.5	95/20 reduction
	15	0.75	4.9	3.6	95/95 reduction
	15	12	3.5	5.0	Low instream demand
	15	0.75	3.4	5.1	Low instream demand
	45	12	2.4	6.2	NPDES effluent[a]
	45	0.75	2.3	6.3	NPDES effluent[a,b]
1995	96	33	5.8	2.7	Average effluent
	115	41	5.9	2.6	Surveyed effluent
	45	12	4.4	4.2	NPDES effluent
	45	0.75	4.4	4.2	NPDES effluent[b]
	15	12	5.4	3.1	95/20 reduction
	15	0.75	5.3	3.2	95/95 reduction
	15	12	4.0	4.5	Low instream demand
	15	0.75	3.9	4.6	Low instream demand
	45	12	2.4	6.2	NPDES effluent[a]
	45	0.75	2.3	6.3	NPDES effluent[a,b]

[a] Effluent DO = 6.0 [b] Additional ammonia removal

Source: Assessment Report and Recommendations, PRAPO Planning Area, Water Resources Research Institute, p. 47.

Municipal Point Sources

The analyses and findings concerning municipal point sources were described in the document, "Water Quality Model Applications: Johnson, Sheridan and Campbell Counties, Wyoming" by Water Resources Research Institute. The major features addressed in that study were the type and sophistication of the models used, the severity of the present and expected problems and the amount and type of treatment necessary to achieve "fishable-swimmable" waters. Tables 29, 31 and 33 present the current and expected waste loads utilized during the model evaluations. The most limited Nitrogeneous Biochemical Oxygen Demand (NBOD) values listed resulted from calculations provided by the Department of Environmental Quality and represent the allowable ammonia concentration with no toxic effects. Tables 30, 32, 34 and 35 present the results of the model evaluations. These data show that dissolved oxygen concentrations will probably be maintained

TABLE 31

Present and Expected Waste Loads:

Clear Creek, Buffalo, Wyoming

Facility Plan Design Population for 1995 17,513

		Waste Loads		
Year	Population	Flow (cfs)	CBOD (mg/l)	Comments
1976	4,200	1.00	59.0	Present conditions
1982	5,800	1.35	59.0	No additional treatment
	8,200	1.90	59.0	No additional treatment
	8,300	1.90	59.0	No additional treatment
	5,800	1.35	45.0	NPDES standard
	8,200	1.90	45.0	NPDES standard
	8,300	1.90	45.0	NPDES standard
	5,800	1.35	5.7	95/20 reduction
	8,200	1.90	5.7	95/20 reduction
	8,300	1.90	5.7	95/20 reduction
	5,800	1.35	5.7	95/95 reduction
	8,200	1.90	5.7	95/95 reduction
	8,300	1.90	5.7	95/95 reduction
	8,200	1.90	140.0	Winter values
1995	10,600	2.45	59.0	No additional treatment
	18,300	4.30	59.0	No additional treatment
	18,900	4.30	59.0	No additional treatment
	10,600	2.45	45.0	NPDES standards
	18,300	4.30	45.0	NPDES standards
	18,900	4.30	45.0	NPDES standards
	10,600	2.45	5.7	95/20 reduction
	18,300	4.30	5.7	95/20 reduction
	18,900	4.30	5.7	95/20 reduction
	10,600	2.45	5.7	95/95 reduction
	18,300	4.30	5.7	95/95 reduction
	18,900	4.30	5.7	95/95 reduction
	18,300	4.30	140.0	Winter values

Source: Assessment Report and Recommendations, PRAPO Planning Area, Water Resources Research Institute, p. 46.

TABLE 32

Clear Creek Dissolved Oxygen Response

Year	Ultimate Waste Load CBOD (mg/l)	Ultimate Waste Load NBOD (mg/l)	Maximum DO Deficit (mg/l)	DO Level at Maximum Deficit (mg/l)	Comments
1982	59	12	2.8	5.5	Surveyed effluent
	45	7.6	2.8	5.5	NPDES effluent
	45	7.6	3.2	5.0	NPDES effluent[a]
	5.7	20	2.8	5.5	95/20 reduction
	5.7	1.25	2.8	5.5	95/95 reduction
	5.7	20	1.2	7.1	Low instream demand
	5.7	1.25	1.1	7.2	Low instream demand
1995	59	12	2.5	5.8	Surveyed effluent
	45	7.6	2.5	5.8	NPDES effluent
	45	7.6	3.4	4.9	NPDES effluent[a]
	5.7	20	2.5	5.8	95/20 reduction
	5.7	1.25	2.5	5.8	95/95 reduction
	5.7	20	1.0	7.2	Low instream demand
	5.7	1.25	0.9	7.4	Low instream demand
	140	21	3.0	7.8	Winter values

[a] Effluent DO = 3.0

Source: Assessment Report and Recommendations, PRAPO Planning Area, Water Resources Research Institute, p. 48.

TABLE 33

Waste Loads to Donkey Creek with Secondary Treatment

Facility Plan Design Population for 1997 40.000

Source	Design Population	Flow (MGD)	BOD_5 (#/day)	NH_3 - N (#/day)	UBOD* (#/day)	NH_3 - N* (#/day)	UBOD* (#/day)
Gillette, 1976	13,000	1.00	87.5	124.5	212	14.5	102
Gillette, 1977	18,540	1.92	168.0	239.0	407	27.0	195
Gillette, 1978	20,450	2.12	185.0	264.0	449	34.0	219
Gillette, 1979	33.240	2.41	211.0	300.0	511	39.0	250
Gillette, 1985	28,540	2.96	259.0	368.0	627	42.0	301
Gillette, 1995	34,200	3.54	309.5	440.5	750	50.5	360

*With nitrification.

Source: Assessment Report and Recommendations, PRAPO Planning Area, Water Resources Research Institute, p. 47.

TABLE 34

Critical Deficit (Dc) with Secondary Treatment: Stonepile-Donkey Creek

Source	Design Population	Op Flow (MGD)	Ka	Kd	$\Phi = \frac{Ka}{Kd}$	$Lo = \frac{UBOD}{Qt \times 8.34}$	$Dc = Lo\ \Phi^{(\Phi/1-\Phi)}$	Cs - Dc
Gillette 1976	13,000	1.00	12.50	3.94	3.94	25.4	4.70	3.12
Gillette 1977	18,540	1.92	3.24	3.94	.8223	25.4	10.27	0
Gillette 1978	20,450	2.12	2.63	3.94	.6690	25.4	11.27	0
Gillette 1979	23,240	2.41	2.03	3.94	.5152	25.4	13.90	0
Gillette 1985	28,540	2.96	1.32	3.94	.3350	25.4	14.64	0
Gillette	34,200	3.54	.9160	3.94	.2325	25.4	16.32	0

Source: Assessment Report and Recommendations, PRAPO Planning Area, Water Resources Research Institute, p. 48.

TABLE 35

Critical Deficit (Dc) With Secondary Treatment Plus Nitrification: Stonepile-Donkey Creek

Source	Design Population	Op Flow (MGD)	Ka	Kd	$\Phi = \frac{Ka}{Kd}$	$Lo = \frac{UBOD}{Qt \times 8.34}$	$Dc = Lo\ \Phi^{(\Phi/1-\Phi)}$	Cs - Dc
Gillette 1976	13,000	1.00	12.50	3.94	3.17	12.20	2.26	5.56
Gillette 1977	18,540	1.92	3.24	3.94	.8223	12.20	4.93	2.89
Gillette 1978	20,450	2.12	2.63	3.94	.6690	12.20	5.41	2.41
Gillette 1979	23,240	2.41	2.03	3.94	.5152	12.20	5.86	1.96
Gillette 1985	28,540	2.96	1.32	3.94	.3350	12.20	7.03	.79
Gillette 1995	34.200	3.54	.9160	3.94	.2325	12.20	7.84	0

Source: Assessment Report and Recommendations, PRAPO Planning Area, Water Resources Research Institute, p. 49.

at acceptable levels by applying 1977 standards, but that some form of advanced treatment may be required before ammonia concentrations can be lowered to nontoxic levels. At the present time, the toxicity problem is being studied by various governmental agencies and cities of Sheridan and Buffalo to determine what level of treatment will be necessary.

National Pollutant Discharge Elimination System (NPDES)

The National Pollutant Discharge Elimination System permit is the tool to ensure that effluent limitations and instream water quality goals are met. It is illegal to discharge any pollutant into the nation's water without an NPDES permit. Failure to comply with the limitations of the permit may lead to fines of up to $10,000 per day.

A total of 77 NPDES permits were issued through February, 1978, in Sheridan, Johnson and Campbell Counties as identified by the Department of Environmental Quality. In addition, an Environmental Protection Agency printout was also obtained to compare the limitation stated in the permit to discharge compliance by permit holders. The seventy-seven permits from the three counties were separated into one of three classifications (agriculture, domestic or industrial) and analyzed for compliance. Additionally, each category was subdivided into the following categories:

Agriculture
  Feedlots and fish hatcheries

Domestic
  Commercial
  Municipal
  Federal
  State

Industrial

- Oil wells
- Coal mines
- Gas plants
- Electric generators
- Water treatment plants
- Sand and gravel processors

Table 36 presents permit totals by county, category and drainage basin while Table 37 itemizes the overall NPDES program in the Powder River Areawide Planning Organization planning area.

A review of discharge data for those point sources permitted under the NPDES system reveals two categories of discharges which have a continuing effect on the water quality of receiving streams. These two categories are oil well treaters in the Powder River drainage, especially Salt Creek, and discharges from municipal wastewater treatment facilities.

Oil and grease most frequently violate the discharge limitations on oil well treaters; however, high levels of total dissolved solids in the discharges have the greatest effect on instream water quality. Effluent limitations are generally set at 5000 mg/l. TDS. Salt Creek, which derives all of its continuous flow from produced water discharges, accounts for the largest man-related source of pollution in the Powder River drainage. Over forty oil well discharges are located on Salt Creek, the majority of them located in Natrona County. These point sources discharge an average of 42 cfs of water, which carries 457 tons of salts per day. About 30 cfs and 336 tons per day reach the Powder River, which amounts to 26 percent of the salt load in the river. Elimination of all discharges on Salt Creek would theoretically reduce the total dissolved solids concentration in the Powder River, at the state line, from 1375 mg/l. to 840 mg/l. Reduction of the salt load from these discharges by 50 percent while flow remained the same, would reduce the total dissolved solids concentration from 1375 mg/l. to 920 mg/l. Local agricultural representatives have indicated that the loss of water from the discharges would prove more detrimental to their operations than the high salinity load now does. Oil well treater dis-

TABLE 36

Summary Table: NPDES Program, PRAPO Planning Area

Category	CAMPBELL COUNTY RIVER BASINS					SHERIDAN COUNTY RIVER BASINS				JOHNSON COUNTY POWDER RIVER BASIN	
	Powder River	Belle Fourche River	Cheyenne River	Little Missouri River	Total	Powder River	Tongue River	Big Horn River	Total	Powder River	TOTAL
Agriculture											
Feedlots and fish hatcheries						1	1		2		2
Domestic											
Commercial	4	7	1		12		2		2	4	18
Municipal		1			1		2		2	2	5
Federal							2	1	3		3
State							1		1	2	3
TOTAL											29
Industrial											
Oil well	5			2	7					21	28
Coal mine	2	5	2		9		2		2		11
Gas plant										1	1
Electric generation		1			1						1
Water treatment							3		3	1	4
Sand and gravel										1	1
TOTAL											46
TOTALS	11	14	3	2	30	1	13	1	15	32	77

Source: Assessment Report and Recommendations, PRAPO Planning Area, Water Resources Research Institute, p. 50.

TABLE 37

NPDES Results: PRAPO Planning Area

Category	Percent of Compliance			Percent of Missing Data		
	$\bar{x}$ (%)	SD (%)	Data Available (%)	$\bar{x}$ (%)	SD (%)	Data Available (%)
Agricultural	100	0	100	0	0	100
Domestic	92.11	5.8	39	.93	2.58	65
Ind. oilwell	89.74	11.82	82	4.64	7.82	100
Ind. coal mine	92.00	4.58	30	2.78	5.95	90
Ind. misc.	81.83	17.75	100	0	0	100
Total $\bar{x}$	91.14	7.99	70.20	1.67	3.27	91.00
SD	6.50	6.90	33.56	2.01	3.53	15.17

Source: Assessment Report and Recommendations, PRAPO Planning Area, Water Resources Research Institute, p. 51.

charges on the South Fork and North Fork of the Powder River also contribute to the salt load in the mainstem. However, their total contribution amounts to only 20 tons per day or about 2 percent of the Powder River salt load.

Discharges from municipal wastewater facilities are the second category of point sources which have the greatest influence on water quality. In the three county area there are five municipal wastewater discharges; they include the cities of Gillette, Buffalo and Sheridan, as well as the towns of Ranchester and Kaycee. These municipalities, except Gillette, although permitted under NPDES and required to monitor their effluent, are not yet required to meet secondary treatment standards. Gillette's sewage treatment facility was constructed with Federal funds and is therefore required to meet the standards. In the last two years, the efficiency of this plant has deterioated due to the large population influx. At present, the system is no longer capable of meeting its effluent limitations.

The facilities at Ranchester and Kaycee are limited in size. Monitoring at Ranchester indicates that the system is functioning properly and meeting secondary treatment limitations. Kaycee's system, however, is not capable of meeting the secondary treatment limitations. Organic material and fecal coliform bacteria are the major problems with this system. Both Ranchester and Kaycee are experiencing increased population growth which will cause overloading of the present systems.

Sheridan and Buffalo are the two facilities which have the greatest effect on instream water quality due to their ineffectiveness, the larger population that they serve, and both discharge into Class I streams. High concentrations of organic material and suspended solids in their discharges create limitations on aquatic life below the discharge points, while high concentrations of fecal coliform bacteria limit primary contact recreation. Questions have been raised as to whether enforcement of secondary treatment standards on these two systems will be sufficient. Federal and state agencies along with the cities are now studying the problem to determine whether advanced treatment will be required to lower ammonia and chlorine concentrations below toxic levels.

All five of these communities have taken the first step in upgrading their facilities. As additional Federal funds become available these facilities will be upgarded and effluent limitations will then be applied to the permits.

Other point sources in the planning area do not create the same impact as do oil well treaters and municipal dischargers. There are a number of private sewage systems, as well as systems operated by Federal and state agencies, in the planning area. These systems are required to meet secondary treatment standards at their inception. Except for occasional violations, these systems discharge effluent which meets their permit limitations. There are a total of eleven coal mines in the planning area which have discharge permits issued to them. In 1977, only four of these mines were actually discharging. Other than a few suspended solids violations, the mines were able to meet their permit limitations.

In general, the point source problems are not caused by violation of permit limitations, but rather by the lack of limitations on permits or by effluent limitations which are established at a high level.

Meeting of Water Quality Standards

The Water Resources Research Institute prepared an evaluation of the effectiveness of the State's proposed water quality standards and recommended alterations in the stream segment classifications listed in the 303e basin plan for Northeast Wyoming.

The proposed water quality standards are shown in Appendix B of this report. Changes may be made in these standards due to the fact that they had not been fully approved at the time this report was written.

A major change in the proposed standards calls for expansion of stream classifications from three to four, with the new Class I streams being those of unique value which will be maintained at their existing quality. Other changes include the setting of specific limits for unionized ammonia and chlorine in Class II and III waters, as well as expansion of the number of streams which must meet primary contact recreation limits for fecal coliform bacteria. The change which will probably have the greatest impact on land management agencies is the one which states that, where water quality is impacted by various land use practices, best management practices to protect the water quality will be developed in accordance with the State Continuing Planning Process. Certification of the best management practices will be the responsibility of the Administration of the Water Quality Division.

In the 303e basin plan for Northeast Wyoming, Goose Creek was designated as effluent limited for its entire length and Clear Creek was listed as doubtful subject to further analysis. Based upon the simulation modeling effort previously reported in this document, it appears as if both streams can meet water quality standards for dissolved oxygen and coliform with properly constructed and operating secondary waste treatment facilities. Within the Goose Creek drainage this effort will also require that illegal septic tank discharges be eliminated. In both stream systems it appears unlikely that secondary treatment will remove sufficient ammonia to prevent toxic concentrations in receiving streams at the design flow ($Q_{7,10}$). In each instance, toxic concentrations could be observed in the reaches immediately downstream of the outfalls. Although this has occurred, it is recommended that Goose and Clear Creek be considered effluent limited subject to additional analyses at a date when facilities construction is completed and operational.

SOLID WASTE MANAGEMENT AND AIR QUALITY RELATED TO WATER QUALITY

Potential Water Pollution From Solid Waste Disposal

Solid waste land disposal sites can be sources of groundwater contamination due to the generation of leachate caused by water percolating through concentrations of refuse and waste materials. Precipitation falling on a site either becomes runoff, returns to the atmosphere via evaporation and transpiration, or infiltrates the landfill. Contamination problems are more likely to occur in humid areas, where the moisture available exceeds the ability of the waste pile to absorb water.

Problems presently associated with existing or abandoned dumps and landfills should not be considered in the same category as potential problems at new, properly designed sanitary landfills because there are methods available for minimizing environmental effects and managing leachate production. Proper siting in locations where potential contamination of groundwater is limited is one method. Reduction of leachate formation by use of selected cover materials and surface grading of the refuse pile consists of another method. Others which are costly include pre-treatment capable of reducing the volume or solubility of the waste, detoxification of hazardous wastes prior to disposal, and collection of the leachate by means of impermeable barriers or liners, followed by treatment.

At the present time there is no effective Federal regulatory control of land disposal of solid waste except as it may enter navigable waters.

Solid Waste Management Practices In the Three County Area[1]

In rural agricultural counties similar to those in the Powder River area, solid waste management is a relatively simple procedure. Basically, it consists of solid waste generation, collection, and disposal. There are none of the complex practices of waste disposal which are found in large metropolitan areas. Systems such as recycling and energy recovery are expensive and require large quantities of solid waste which make them impractical in the three counties. The most effective system of solid waste disposal for agricultural counties is the sanitary landfill. In the three-county area, there are three major landfills, one each in Buffalo, Gillette and Sheridan. These landfills serve those communities and most of the county-wide areas which surround them. The towns of Clearmont in Sheridan County and Kaycee in Johnson County maintain their own landfills.

Buffalo

The City of Buffalo and its surrounding area generate approximately 2,900 tons of solid waste annually. Since the population of the Buffalo area amounts to approximately 5,000, the solid waste generation amounts to three pounds per capita per day.

The landfill used for general solid waste disposal is located southeast of the City on a site of 49.5 acres. It is not used for the disposal of sewage sludge or septage.

The north end of the facility contains an embankment to prevent accumulated waters within the landfill area from flowing into nearby draws and possibly reaching surface waters. The groundwater level is known to be greater than sixty feet deep in the area. The remaining life expectancy for the landfill is approximately twenty years.

Sheridan

The City of Sheridan landfill is the major site serving the City of Sheridan and the County. Approximately 72 tons of solid waste are deposited at the site daily. Based on an estimated population of 18,000 utilizing the facility, the per capita generation of solid waste for the area is approximately eight pounds per person per day.

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[1] This section and the Summary comments section are based on material prepared by the staff of the Powder River Areawide Planning Organization.

The landfill site is located due east of the City. It is used for general solid waste disposal from the surrounding area. In the first four months of 1977 , 33.75 tons of dewatered sludge from the Sheridan sewage treatment plant was deposited in trenches at the landfill. Septage is not directly deposited at the landfill.

The groundwater level in the area is about 110 feet below the surface. The geology is predominantly shale, sandstone and coal. Drainage pipe is installed throughout the landfill to remove accumulated waters. There are no surface waters in close proximity, but the landfill is located upslope from Little Goose Creek which is one-half to one mile from the site. There are a number of residences with private wells located down gradient from the landfill. The remaining life expectancy of the Sheridan landfill site is ten years.

Gillette

Gillette maintains a landfill southwest of the City. It is the primary landfill serving the City and surrounding areas in the County. Approximately 100 tons of solid waste material are deposited within the landfill daily. The population served by the landfill is estimated to be approximately 20,000 persons. Based on these figures, per capita generation of solid waste in the Gillette area amounts to approximately ten pounds per person per day.

The landfill is utilized for the disposal of general solid waste as well as most material, other than radioactive, which would generally be disposed of in a hazardous waste disposal area. Septage and petroleum are also disposed in the landfill site.

The groundwater level is estimated to be approximately ten feet below the bottom of the site. The geological formations in the area contain large amounts of scoria and coal and there are no surface waters in the vicinity. The life expectancy of the Gillette landfill is estimated to be approximately two years.

Summary Comments

It is believed that no significant water pollution problems are experienced in the area of the landfill sites. However, data pertaining to water quality around the landfills is very minimal.

There are, however, potentials for water quality problems at the Sheridan landfill for the following three reasons:

1. High volumes of waste generation;
2. The existence of private domestic wells in close proximity to the landfill site;
3. The site is located at a higher elevation than Little Goose Creek and is in fairly close proximity to the Creek and the outlying portions of the City.

Due to the geologic formations within the area contiguous to the Gillette landfill and the close proximity of the groundwater level to the bottom of the landfill pit, the potential for the leaching of contaminants into the groundwater is high.

Recommendations Pertaining to Maintenance of Water Quality

Groundwaters around the Sheridan and Gillette landfill sites should be monitored to determine whether there are any adverse effects caused by the landfill operation. This could primarily be accomplished in the Sheridan area by monitoring existing domestic wells in the area.

The areas surrounding all of the landfills should be observed and monitored during runoff events to determine whether there is any possibility of contaminants reaching surface waters.

Air Quality[1]

One-third of the Powder River Basin 208 triumvirate is included in another federally funded environmental planning program. Campbell County, along with

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[1] This section is based on material prepared by the staff of the Powder River Area-wide Planning Organization.

Converse County, is classified as an air quality maintenance area (AQMA) for which an air quality maintenance plan (AQMP) must be completed. Under the Federal regulations, water quality plans and AQMP's must be compatible.

An emissions inventory and projections report has been prepared by the Wyoming Department of Environmental Quality - Air Quality Division. This report consideres two basic pollutants, hydrocarbons and particulates.

It is estimated that hydrocarbon emissions in Campbell County will increase from 2,210 tons per year in 1975 to 2,763 tons per year in 1980, with decreases to 2,105 tons by 1985. The greatest source of hydrocarbon pollutants is currently and will continue to be highway travel which will average 71 percent of the total hydrocarbons emitted through 1980. This is estimated to decrease to 57 percent by 1985.

Particulate emissions in Campbell County account for the greatest source of air pollution. In 1975 over 41,192 tons of particulates were emitted. This level is estimated to increase to 62,541 tons by 1980 and 74,824 tons by 1985. The greatest source of particulate emissions amounts to fugitive dust from unpaved roads. In 1975, 79 percent of the total occurred from this source. By 1980 and through 1985, it is projected that 91 percent of particulate pollution will be generated by fugitive dust from unpaved roads. Reasons for this are related to growth factors and the development of the energy industry in the rural areas of the County served by unpaved roads.

It is believed that these factors will not produce any great implications affecting water quality management planning. Indirect effects on water quality could develop if air quality planning determined that large amounts of water were needed to control dust on unpaved roads. These may be a slight change in water quality of surface waters due to airborne particles settling on the waters. However, due to the scarcity of surface waters within Campbell County, this cannot really be considered a problem.

At present there do not appear to be any conflicts between air quality maintenance planning and water quality management planning. Recommendations within this plan have both positive water quality and air quality implications. In Campbell County, particulate emissions around mine sites have reached the problem stage. The implementation of more stringent mining reclamation guidelines as outlined in the mining assessment will help in the protection of water quality, as well as reduce air carried particulates. Unpaved road traffic has shown a large increase in the planning area because of the increased number of rural subdivisions and increased travel to mine sites. Paving of roads in subdivisions with a density of one dwelling per acre or less will decrease sediment and particulate problems. The requirement that mining companies pave major access roads to mine sites would also have a positive effect on these problems. In urban areas, the recommendations for increased street cleaning will also help in the control of urban runoff pollution and the reduction of airborne particulates. Because of the uncertainty of development within the energy and power generation industry, it is unrealistic to try to project any conflicts between air quality and water quality.

Chapter III

NON-POINT SOURCE ASSESSMENT AND NEEDS

INTRODUCTION

The cost of wastewater management increases rapidly as higher levels of treatment are required; the ultimate national goal of zero discharge will require public investment many times present levels. Even with zero discharge of municipal and industrial wastes (point sources), national goals for water quality may not be achieved in some areas because of pollution from non-point sources.

Areas receiving 208 designation are required to carefully evaluate non-point pollutant sources, or sources not related to a point discharge such as sewage treatment plants. An evaluation of non-point sources hopefully leads to the determination of the relative quantity and quality of all pollutant sources within the area. Non-point source pollution is released from urban, agricultural, rural, and forested land uses. The main potential non-point pollutant sources in the three counties originate from urban runoff, mineral extraction, forest land activities, and urban types of development in rural areas.

One of the major aspects in the prevention of non-point source pollution is the development of guidelines or best management practices to assist in the prevention of pollution before it actually occurs. The intent of this section is to recommend preventative guidelines many of which are also being utilized by the Department of Environmental Quality and various Federal agencies.

MINED LANDS ASSESSMENT

Introduction

One of the primary reasons that the Powder River Basin was selected as a 208 planning area was the rapid expansion of energy development in the area. At the time this planning effort was begun, environmental controls on surface mining in the west were not yet fully developed. The program was designed to look at two impacts on water quality from increased mining activities, the indirect impact on social institutions caused by the increased work force and the direct impact caused by the mining operations. This section will deal with the direct impact of mining.

Using data collected previously at ongoing mining operations and supplementing it with data collected during the planning effort, a mined lands assessment was developed, covering mining from the exploration phase through the post mining phase. Suggested management practices, to protect water quality, were developed for each phase of the operation.

During the period in which 208 planning was being undertaken, the Federal government and the State government were taking measures to tighten environmental controls on mining. The Federal government enacted the Surface Mining and Reclamation Act of 1977, which included, among others, provisions for the protection of alluvial valleys and water quality. During the same period, the Land Quality Division of Wyoming's Department of Environmental Quality developed preventive guidelines for surface mining and has taken steps to amend their rules and regulations to conform with the provisions of the new Federal surface mining act. Many of the suggested management practices listed in this text were also developed as preventive guidelines by the DEQ/LQD, and are now being adopted in their revised rules and regulations.

Two things are required by DEQ to fully accomplish their program. First, to ensure that each mining permit application is processed properly and that mining companies adhere to the provisions of their mining permits, additional personnel are needed in the Land Quality Division. Secondly, since the Water Quality Division's new rules and regulations propose that "best management practices" designed to protect water quality must be certified by the WQD Administrator, an intradepartmental cooperative policy must be developed to coordinate the two programs.

Mineral Exploration

Pollution Assessment

The primary activities associated with this phase of a mining operation are the drilling and logging of exploration holes in the areas of interest. The major pollution sources associated with mineral exploration include erosion from the disturbed surface areas surrounding drilled areas and from aquifer degradation associated with the use of drilling fluids and improper methods employed in drilling. Erosion from these sites can constitute a significant problem if drilling activities are initiated during wet periods of the year and are located at sites bordering surface drainages.

Groundwater pollution problems associated with drilling can be more significant. Problems result from the introduction of foreign substances contained in drilling fluids into drinking water aquifers and from techniques which leave drill holes open and do not isolate separate water-bearing strata. Together these practices can introduce foreign and often toxic substances into aquifers serving as the major source of drinking water for an area. This problem is magnified in the Powder River Basin where coal seems often offer the most readily accessible source of water.

At the federal level, control of exploratory drilling rests with the Bureau of Land Management and the United States Geological Survey. At the state level, the Land Quality Division of the Department of Environmental Quality is responsible for regulating the plugging and capping holes and restoration of the drill sites in the exploratory drilling phase.

Recommended Management Practices

Table 38 itemizes recommended practices. Due to regulatory mechanisms currently operable, the most important of these practices is proper inspection of drill sites supported by adequate data collection and evaluation.

TABLE 38

Management Practices: Exploration Phase

Activity	Management Practice	Result	Water Quality Effect
Location building	1. Schedule events for times when surface disturbance can be minimal 2. Use existing roads where possible 3. Require that bonds be posted before exploration begins	1. Reduce erosion 2. Protect future uses of groundwater 3. Establish better control over resource	1. Reduce sedimentation 2. Reduce salinity 3. Reduce groundwater pollution
Drilling	1. Register drillers 2. Pump drilling fluids from holes 3. Isolate drinking water aquifers 4. Plug wells at the surface 5. Establish well data network 6. Drill holes sealed for uranium mining	1. Protect future water uses 2. Control groundwater data 3. Identify present or future problem areas	1. Eliminate or reduce groundwater pollution
Inspection	1. Create enough positions to insure compliance	1. Protect future water uses	1. Reduce surface and groundwater pollution

Source: Water Quality Determinations, Mined Lands Areas, Northeastern Wyoming, Water Resources Research Institute, p. 17.

Mine Initiation

Pollution Assessment

Following the issuance of the various permits needed to mine, and preliminary to actual mineral removal, an extended period of general construction activity occurs at a mine site. This activity maintains a certain level of water pollution potential.

The construction of roads, railroads and shelters removes vegetation which can cause increased erosion. Available information indicates that road building is potentially the most significant source of sediment at a mine site. Yields of over 57,000 tons/square mile/year have been observed from information obtained by the Environmental Protection Agency. This is over 2,000 times the amount of sediment produced at an unmined watershed and about 30 times the amount of sediment produced from the remainder of the mined area. Table 39 itemizes the relative rates of erosion from various land uses.

TABLE 39

Comparative Rates of Erosion From Various Land Uses

Land Use	Metric tons per km^2 per year	Tons per $miles^2$ per year	Relative to forest = 1
Forest	8.5	24	1
Grassland	85.0	240	10
Abandoned surface mines	850.0	2,400	100
Cropland	1,700.0	4,800	200
Harvested forest	4,250.0	12,000	500
Active surface mines	17,000.0	48,000	2,000
Construction	17,000.0	48,000	2,000

Source: Water Quality Determinations, Mined Lands Areas, Northeastern Wyoming, Water Resources Research Institute, p. 21.

While this table was prepared from data collected in the Eastern United States and these figures cannot be applied directly to the three-county planning area, they are useful as comparative indicators of land use-erosion relationships in the mined area.

The pollution potentials associated with the initial stripping and storage of soil and overburden materials include increased sedimentation, salinity and the possible release of toxic elements previously locked in underlying strata. Toxic problems which might be expected to occur with mining in Wyoming include excessive salt concentrations and the presence of heavy metals.

Blasting preparations used in fragmenting the overburden in this phase of activities and the overburden and the coal during the mining phase can contain ammonia and nitrate-nitrogen. Ammonia can be toxic to aquatic life if found in excess of 0.02 mg/l in the unionized form (NH_3). Nitrate can cause problems if found in excess of 45 mg/l (as NO_3) in water regularly consumed by infants. Further, as a nutrient, nitrate often contributes to the eutrophication of lakes and reservoirs. These latter problems are considered to be minor at mine sites when compared to the pollution potentials from municipal waste treatment facilities.

Sanitary wastes at a building site offer potential public health problems. Water-borne diseases can spread rapidly in areas of improper waste treatment. Additionally, nitrates and phosphates are associated with sanitary and washroom facilities. These nutrients can induce algal blooms and eutrophication in lentic receiving waters. This area of pollution control is the best understood and most highly regulated of the categories described. Due to the ease of regulation of this pollutant situation, it is believed that this category offers the least potential for severe pollution.

Recommended Management Practices

The Bureau of Land Management, the United States Forest Service and the United States Geological Survey directly regulate mining operations at the federal level. The Environmental Protection Agency has responsibility for the review of impact statements and can indirectly affect mining activities. At the state level, the Department of Environmental Quality's Land Quality Division exerts the primary agency control over mining in Wyoming. The Land Quality Division is assisted by the Water and Air Quality Divisions within the Department of Environmental Quality and by the Wyoming Game and Fish Commission. If stream channel relocations are necessary, the State Engineer's Office is involved, although primary control is retained in the Land Quality Division.

The management practices suggested for this phase of the mining effort are recommended below.

- Insure that mine plans are being properly implemented.
- Reevaluate the entire site for suitability of mine plan specifics.
- Evaluate specific areas within the mine plan based on newly acquired data.

Specifically, management practices include field inspections, coordinated data collection programs and comprehensive data analysis efforts to verify assumptions promulgated when the mine, reclamation and pollution control plans were formulated. Based on these practices , improvements can be implemented during the mining operational phase.

Table 40 itemizes recommended management practices for the mine initiation phase.

Mining Phase

Pollution Assessment

The transition between the mine initiation and mining phase is not dramatic. Construction of buildings, roads and railroads will decrease but will not be halted completely. Coal production which started in the initiation phase will be accelerated. Stripping activities will continue, but at a lower rate, progressing to the point of occurring directly ahead of mining. Reclamation of initial pits and cuts can be initiated, depending upon the type of mine and the amount of time devoted to preliminary operations.

The activities associated with this phase of mine operations that possess the most severe water pollution potentials are continued road building and maintenance, continued stream channelization, continued stripping and storage, accelerated use of sanitary facilities, and any procedures necessary to prepare the coal for shipping at loadout facilities. Additionally, several potential pollution sources related to groundwater quality could exist. These include the interception and ultimate discharge of naturally occurring groundwaters of poor quality, the introduction of saline or toxic materials into surface aquifers through recharge from sedimentation basins and the creation of toxic or saline waters in spoil storage areas. Pollution from this last source can seep from

TABLE 40

Management Practices: Mine Initiation Phase

Activity	Management Practice	Result	Water Quality Effect
Building Construction	1. Minimize size of disturbed area at any one time 2. Proper sanitary facilities 3. Temporary sediment basins or structures 4. Establish filter or buffer zones	1. Reduce erosion 2. Maintain public health	1. Reduce sedimentation 2. Reduce salinity 3. Lower BOD 4. Lower coliform concentration 5. Maintain DO 6. Lower NH_3 concentration
Road and Railroad Construction	1. Minimize size of disturbed area at any one time 2. Establish grades (less than 10% recommended) 3. Establish filter or buffer zones 4. Reevaluate surface materials (roads and roadbeds) for erosion potential 5. Construct temporary or permanent sediment basins	1. Reduce erosion 2. Lower velocities 3. Retain sediment 4. Alter mine plans	1. Reduce sedimendation 2. Reduce salinity
Stream Channel Alteration	1. Maintain grade 2. Reduce velocities 3. Evaluate basement materials for toxicity, salinity, erosion	1. Reduce erosion 2. Reduce flooding 3. Reduce leaching	1. Reduce sedimentation 2. Reduce salinity 3. Prevent toxic substance discharge

(Table continued)

TABLE 40 , continued

Activity	Management Practice	Result	Water Quality Effect
Stripping, Soil and Overburden Storage	1. Minimize size of disturbed area 2. Construct temporary and permanent sediment basins and structures 3. Reevaluation of storage sites for proximity to water sources as well as grade and slope length 4. Reevaluation of storage materials for toxic, saline or erosion materials as well as reclamation potential 5. Segregate all toxic, saline or highly erosive materials 6. Stabilize stored materials 7. Maintain or establish buffer or filter zones	1. Reduce erosion 2. Retain sediment	1. Reduce sedimentation 2. Reduce salinity

Source: Water Quality Determinations, Mined Lands Areas, Northeastern Wyoming, Water Resources Research Institute, p. 28-29.

the spoil piles to pollute nearby surface waters or can remain in storage. The chemical quality of this source is indicative of future water quality conditions which could be expected in reclaimed pits and cuts.

Generally, pollution yields decrease as the mine reaches full production. This results from the stabilization of exposed surfaces with the associated decrease in the number of sites open to erosion and discharge. Exceptions to this include those operations undertaken at the loadout facilities and the discharge of produced waters from pits completed in the coal seam. Produced waters discharged from active pits can differ chemically from waters produced during initial stripping operations. The interception and subsequent discharge of groundwaters of poor quality can occur.

Produced waters from active pits differ also in terms of the type of suspended solids they can carry. Coal fines replace overburden materials as mining progresses and are generally more difficult to remove through sedimentation.

Groundwater alteration through recharge in strata underlying sedimentation basins is possible. Currently available information would indicate that this will not represent a severe water quality problem in the PRAPO planning area. The only available data base, however, is the National Pollutant Discharge Elimination System data and various studies which characterize the discharge from these basins. This information indicates that groundwater alteration will not be an important pollution source.

The last source of potential groundwater pollution during this phase of mining activity is that originating in spoil storage areas. Water in storage in these areas can contact highly toxic or saline materials. Seepage from these areas can pollute surface sources, while the establishment of hydraulic connections with other aquifers can introduce pollutants into existing or potential water sources. Monitoring these sources and column leaching experiments at higher temperatures can serve as a barometer of future groundwater quality in reclaimed pits and cuts.

Recommended Management Practices

The recommended activities for this phase of the mining effort include:

- Expansion and reevaluation of the data base.
- Reevaluation of the reclamation plans.
- Implementation of those pollution control practices included in the mine plan or supplementary documents.
- Proper inspection and enforcement to insure compliance.

Specifically, these recommendations take the form of continuation and expansion, if necessary, of basic monitoring networks. Information should be obtained for water as well as soils and overburden prior to the actual mining operations. These data should yield information about potential erosion and salinity problems. Additionally, the amount and quality of groundwaters to be encountered should be described. This information can assist in reevaluating mining, reclamation and pollution control plans if necessary.

The second management activity in this phase is to insure that those practices agreed to in the Mine Plan or in subsequent documents are being implemented. Mine configurations change daily, and it is important to insure that the best possible pollution control practices are properly implemented with each stage of alteration. To be undertaken properly this requires that sufficient numbers of well trained individuals make frequent unscheduled inspections. The expansion of the Department of Environmental Quality's field offices to include water quality personnel is recommended.

Other management practices are suggested in Table 41 . During the mining phase it is important for the mining operator and the regulatory agencies to implement a framework which not only addresses specific problems, but also evaluates each site in terms of its short and long term pollution potentials. While it is important to collect problem specific monitoring data, it is more important to establish procedures and programs which are reflective of the long term conditions at the mine site.

Post-Mining Phase

Pollution Assessment

Actual reclamation of a mining operation begins when the mining of a pit area is completed. As the mining operation expands to new locations, backfilling, grading, and contouring of the old pit area is initiated. Depending upon the

TABLE 41

Management Practices: Mining Phase

Activity	Management Practice	Result	Water Quality Effect
Road Building	1. Minimize size of disturbed area at any one time 2. Proper grade control 3. Establish filter or buffer zones 4. Construct temporary or permanent sediment basins and/or structures as necessary	1. Reduce erosion 2. Retain sediment	1. Reduce salinity 2. Reduce sedimentation
Stripping and Storing	1. Minimize size of disturbed area at any one time 2. Construct temporary or permanent sediment basins and/or structures as necessary 3. Segregate toxic, saline or highly erosive materials 4. Stabilize stored materials 5. Establish filter zones 6. Establish monitoring programs to collect soil, overburden and water data at ahead-of-mining sites 7. Reevaluate reclamation and pollution control plans 8. Reevaluate seed and plant materials selection	1. Reduce erosion 2. Retain sediment	1. Reduce salinity 2. Reduce sedimentation 3. Prevent toxic substance discharge 4. Enhance reclamation potentials

Source: Water Quality Determinations, Mined Lands Areas, Northeastern Wyoming, Water Resources Research Institute, p. 35.

size of the initial cuts and the intensity of effort at the mine, the events can begin within a few years of mine initiation.

Reclamation of final pits, cuts, roads, if necessary, and all other disturbed areas begins at the conclusion of mining activities. This process is essentially simpler than continuing reclamation practices previously attempted in that there are no concomitant mining efforts which require synchronous planning and implementation. The ultimate goal of these and all other reclamation activities is to restore the land to a level of equal or improved use.

In addition to potential sources of sediment and salinity in connection with storage areas, and continuing reclamation efforts practiced during mining, two other potential pollution sources exist. These are the possible creation of highly saline or toxic groundwaters in the reclaimed areas and the potential for the establishment of closed basins from which there is little or no surface drainage.

The establishment of saline or toxic groundwaters in reclaimed pit areas occurs when chemical substances are leached from the materials used to reclaim the pit area. These chemical substances can be simple salts or can consist of exotic trace elements and metals. Their presence in a water can render it unuseable or even dangerous to animals and humans.

The second major potential source of pollution which exists for this phase of mining activity is the salinity problem associated with closed basins which result from insufficient materials being present to reestablish premining gradients along surface drains following mining. To reclaim the deep pits with adequate materials following mining can present problems. Either a large amount of fill will have to be borrowed from nearby hillsides or a lake will have to be established in the final cut.

If water is present in an area and if a lake on the property falls within criteria for a higher post-mine land use, then this alternative is a viable one. The water quality problems associated with this option are evaporative concentration within the system. However, if sufficient water is present evaporative concentration will not occur over the long run. The creation of a closed basin will result if insufficient water is present, presenting problems more severe than those previously discussed.

Recommended Management Practices

The Bureau of Land Management and the Land Quality Division of the Department of Environmental Quality will retain reclamation bonds, which were posted when the mine permit was granted, until satisfactory reclamation is achieved. There are no time limits involved in retaining these bonds.

The recommended course of action for insuring proper reclamation and pollution control for this phase of mining operations should be formulated during continuing reclamation programs undertaken during the mining phase.

To insure that materials obtained from nearby areas to establish adequate grades in a reclaimed pit are not potential sources of pollution themselves, standard chemical and physical evaluations should be conducted. If these materials or any other fill materials produce severe salinity or toxicity problems they should be segregated from all sources of water. Additionally, accurate records of the location of these areas should be maintained.

Prevention of closed drainage basins and the associated evaporative concentrations requires that proper surface drainage through the site be accomplished. Final gradients and proper stream meanders must be established in order to allow efficient drainage while minimizing erosion.

Table 42 presents these and other management practices which should be employed during this phase of the mining effort.

TABLE 42

Management Practices: Post-Mining Phase

Activity	Management Practice	Result	Water Quality Effect
Reclaim pit areas, roads, and other affected areas	1. Evaluate fill materials 2. Establish proper gradients 3. Reestablish proper meander system 4. Control velocities and depths 5. Select proper plant materials 6. Establish temporary sediment basins or traps if necessary 7. Continue monitoring programs 8. Retain bonds until reclamation complete	1. Protect ground 2. Reduce erosion 3. Retain sediment 4. Collect valuable future data 5. Protect future water uses	1. Generates new pollution control measures 2. Reduce sediment 3. Reduce surface and subsurface salinity

Source: Water Quality Determinations, Mined Lands Areas, Northeastern Wyoming, Water Resources Research Institute, p. 37.

Mined Lands Program

The previous sections provided an overview of pollution problems and recommendations pertaining to site specific best management practices. On a programmatic level, a recommendation is that a formal water resource evaluation be undertaken and reported for each proposed mining effort in the three county area. Data collection for this evaluation would be undertaken in conjunction with the exploration and permit application phases and would be the responsibility of the operator. The necessary data required for this program would be of the amount and type already being provided by responsible operators. These data should be included with other materials comprising the mine permit application. Specifically, the required materials should include:

1. An identification of all water sources on the property to be affected or within its sphere of influence. This should include determinations of quantity and quality of each surface and ground water source as well as acquifer properties.
2. An identification of those chemical and physical properties of the soil, overburden and mineral materials which will be affected by mining. These analyses should include indexes of erodibility, salinity and toxic substance production.
3. A description of the effects of mining on each water source. This information would be presented in the water resources section of the mining plan.

The degree to which the mining operator should be required to develop a pollution control plan is dependent upon the site's potential for pollution generation and the susceptibility of the site and surrounding areas to the pollutants produced. This can only be determined by a site evaluation conducted after the data collection programs are completed. The site evaluation should be conducted by federal and state personnel with the results subjected to the same type of public review as are the mine permit applications. If the site evaluation identifies areas of severe pollution potential or essentially vulnerable sites or areas within sites, then a major pollution control effort is warranted. This effort should identify the important pollution problems to be controlled and then proceed with the necessary management programs.

Following the formal identification and announcement of these or other potential problems by the regulatory groups, the operator would be required to develop a pollution control program to mitigate potential damages. This program would be developed simultaneously in conjunction with the mine permit application, and be subject to the same type of public review and input. The program should be broad based and offer alternative and backup management practices for the most severe pollutants and susceptible sites.

After a pollution control plan has been formulated, periodic and thorough inspections of each mining effort should be conducted in the area. These inspections are required in the recently enacted Federal strip mine law and should be structured to evaluate compliance with and the effectiveness of the mine plan. The investigations should be used in conjunction with the recommended monitoring data to reevaluate the mining, pollution control and reclamation plans.

In summary, the primary goal is the establishment of a programmatic approach to water pollution assessment and control through which the various levels of government, mining companies and concerned citizenry could work to maintain or improve an area's water quality. It is recommended that a six-part program be established involving governmental as well as industrial contributions. Public or local involvement is assured through similar mechanisms and at similar times as are the mining and reclamation portions of the effort. Additionally, by requiring the regulatory agencies to itemize the pollution potentials and site susceptibilities of a property before it is mined the concerned public is in a position to better evaluate the proposed development and provide more substantive contributions to the process. Table 43 itemizes the recommended program in the approximate chronological sequence through which it develops.

Table 43 Mined Lands: Water Quality Management Program

Program Item	Responsible Contributor	Program Output	Public Contributions
1 Preliminary Data Collection	Operator	Identify Potential Problems	Review and Input
2 Water Resources Evaluation a. Site-Area Evaluations b. Pollutant Evaluations	Regulatory Agencies	Water Resources Section of the Mining Plan	Review and Input
3 Pollution Control Plan a. Sediment Control b. Salinity Control c. Toxic Controls	Operator	Protect Surface and Ground Waters	Review and Input
4 Mine Inspections	Regulatory Agencies	Compliance Assurance Reevaluate Controls	Review and Input
5 Supplementary Monitoring Programs	Agencies and Operator	Data Base for Future Decisions 1. Reevaluate Plans A. Mining B. Reclamation C. Pollution Control	None
6 Reevaluation Programs	Agencies and Operator	Alter Plans 1. Mining 2. Reclamation 3. Pollution Control	Review and Input

Source: Water Quality Determinations Mined Lands Areas, Northeastern Wyoming, Water Resources Research Institute, p. 47.

FORESTED LAND ACTIVITY ASSESSMENT

Introduction

The following six components of forested land activities have been identified as having the greatest water pollution potential in the forested lands under study. These include: 1) recreation; 2) silviculture; 3) livestock and wildlife management; 4) mineral development; 5) transportation development; and 6) fire and post-fire management.

Each of these six components, if improperly managed, will offer significant water pollution potential. This section attempts to assess the pollution potential and to recommend best management practices for maintenance of water quality on forested lands.

Water chemistry, suspended sediment, water discharge and bacteriological concentrations are sampled at long-term baseline or benchmark sites, which are carefully selected on major streams below known activity sites so problems can be isolated to insure quality management of the water resources. Monitoring programs have been established to collectively measure water quality and quantity. Certain activities such as timber sales or specific types of recreation warrant on-site analyses upstream and downstream over given periods of time. Data from on-site and downstream monitoring can offer evidence to support or alter management plans. Physical observations of stream channels and the surrounding area are also part of the analysis procedure.

The United States Forest Service and the Geological Survey maintain monitoring programs. Future hydrological monitoring by the State and the Bureau of Land Management should supplement individual watershed analyses. The basic analysis procedure for site preparation concerning forested land utilization is contained in Table 44 .

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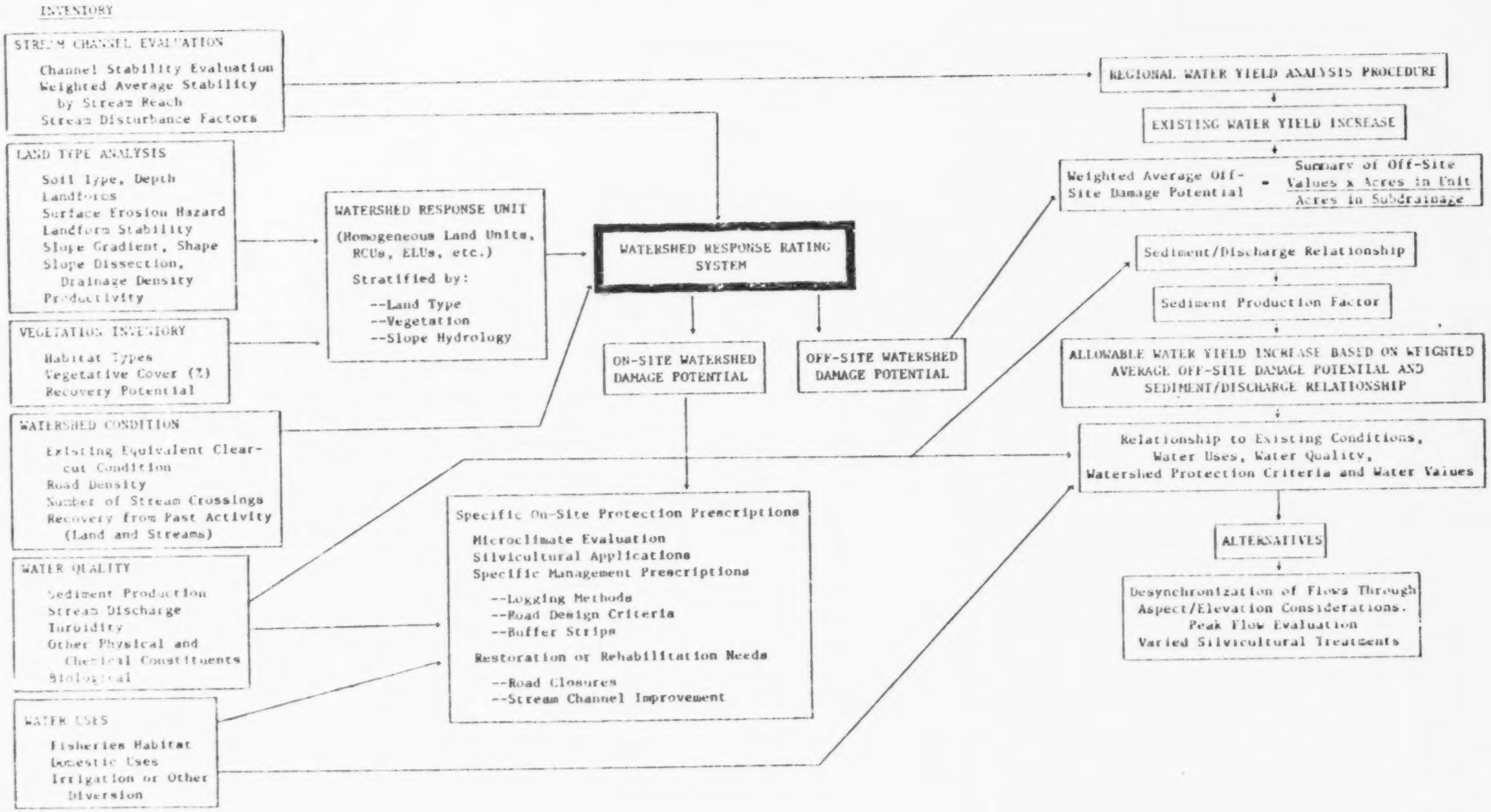
TABLE 44
ANALYSIS PROCEDURE


INVENTORY
STREAM CHANNEL EVALUATION
Channel Stability Evaluation
Weighted Average Stability by Stream Reach
Stream Disturbance Factors
LAND TYPE ANALYSIS
Soil Type, Depth
Landforms
Surface Erosion Hazard
Landform Stability
Slope Gradient, Shape
Slope Dissection, Drainage Density
Productivity
VEGETATION INVENTORY
Habitat Types
Vegetative Cover (%)
Recovery Potential
WATERSHED CONDITION
Existing Equivalent Clear-cut Condition
Road Density
Number of Stream Crossings
Recovery from Past Activity (Land and Streams)
WATER QUALITY
Sediment Production
Stream Discharge
Turbidity
Other Physical and Chemical Constituents
Biological
WATER USES
Fisheries Habitat
Domestic Uses
Irrigation or Other Diversion
WATERSHED RESPONSE UNIT
(Homogeneous Land Units, RCUs, ELUs, etc.)
Stratified by:
--Land Type
--Vegetation
--Slope Hydrology
WATERSHED RESPONSE RATING SYSTEM
ON-SITE WATERSHED DAMAGE POTENTIAL
OFF-SITE WATERSHED DAMAGE POTENTIAL
Specific On-Site Protection Prescriptions
Microclimate Evaluation
Silvicultural Applications
Specific Management Prescriptions
--Logging Methods
--Road Design Criteria
--Buffer Strips
Restoration or Rehabilitation Needs
--Road Closures
--Stream Channel Improvement
REGIONAL WATER YIELD ANALYSIS PROCEDURE
EXISTING WATER YIELD INCREASE
Weighted Average Off-Site Damage Potential = Summary of Off-Site Values x Acres in Unit / Acres in Subdrainage
Sediment/Discharge Relationship
Sediment Production Factor
ALLOWABLE WATER YIELD INCREASE BASED ON WEIGHTED AVERAGE OFF-SITE DAMAGE POTENTIAL AND SEDIMENT/DISCHARGE RELATIONSHIP
Relationship to Existing Conditions, Water Uses, Water Quality, Watershed Protection Criteria and Water Values
ALTERNATIVES
Desynchronization of Flows Through Aspect/Elevation Considerations.
Peak Flow Evaluation
Varied Silvicultural Treatments

Source: Water Quality Management Considerations, Forested Lands Areas, Northeastern Wyoming, Water Resources Research Institute p. 24.

Variations and modifications from this procedure should be undertaken to accommodate specific projects and problems.

Recreation

Pollution Assessment

Virtually all accessible portions of the forested lands in Johnson, Sheridan and Campbell Counties are utilized to various degrees for recreational activities such as camping, picnicking, hunting, fishing, hiking and recreational vehicle driving. The major recreational areas are identified on Map 8 following page 26 . The Bureau of Land Management and the Forest Service have developed management programs emphasizing a balance between utilization and conservation of the habitat to accommodate the influx of population on forested lands.

Designing facilities to accommodate concentrated population impacts are high-priority projects. Construction of self-contained sanitation facilities, improvements in campground sophistication and development of adequate water supplies will minimize pollution potential due to recreation-related activities. These activities are addressed in unit and project plans of federal and state agencies.

Increased bacteriological and erosion/sedimendation contamination may result from recreational activities. Hiking, vehicle misuse and horses used for packing/outfitting can induce ground disturbances, especially over periods of years on the same trails. Under specific conditions high erosion potential may exist. Bacteriological contamination of the habitat is possible through excretion of waste from humans and animals.

When federal and state agencies plan for recreational developments several physical analyses are performed by specialists to evaluate construction. Construction controls are also monitored to minimize land deformation, sedimentation potential, stream damage and other watershed impacts.

Potential point pollution contributors can be linked directly to increased population impacts. Resorts, summer home groups, special-use camps and popular campgrounds potentially contribute to bacteriological contamination of streams and groundwater through direct discharge and septic tank leakage. Bacteriological injection by humans into water systems results from lack of or inadequate sewage disposal facilities in developed or undeveloped areas.

As part of the 1976 PRAPO-Forest Service cooperative agreement, a bacteriological study was conducted in the Cloud Peak Primitive Area near Seven Brothers Lakes to investigate possible contamination due to heavy use in the wilderness. Table 45 shows the results of the fecal coliform study. The control sites netted one coliform out of eight samples, indicating low levels of natural pollution. The counts never exceeded four coliforms per 100 ml at any one site. Twenty-two (22) samples from camping areas produced nine coliforms, an insignificant basis to conclude that these areas are contributing factors.

TABLE 45

Cloud Peak Primitive Area Fecal Coliform Study

Seven Brothers Lakes

Site	Number Samples	Minimum Colonies Per Site	Maximum Colonies Per Site	Total Colonies All Sites	Mean Colonies Per Sample
Control area	8	0	1	1	0.125
Camp area	22	0	4	9	0.4
Trail area	33	0	4	13	0.4
Lake inlet and outlet	8	0	2	2	0.25

Source: Water Quality Management Considerations, Forested Lands Areas, Northeastern Wyoming, Water Resources Research Institute, p. 27.

The most fecal colonies were found on August 12, 1976 when sites around horse fecal material on trails were sampled. Eight samples taken at lake inlets and outlets netted two colonies, indicating pollution of one lake probably does not contribute to the pollution of another.

Bacteriological and chemical sampling was also conducted at sub-basin locations isolating several resorts and lodges as part of the PRAPO-Forest Service contract. Noted increases in bacteriological concentration were observed near heavy use areas (Table 46). Possible bacterial sources could be livestock corrals at the resorts.

TABLE 46

Chemical and Bacterial Examination of Select Lodges and Picnic Areas
Bighorn National Forest

	Hardness (ppm)	TDS (ppm)	Sulfates (ppm)	Nitrates (ppm)	Total Coliforms (per ml)	Fecal Coliforms (per 100 mls)	Fecal Streps (per 100 mls)	FC/FS
TONGUE DISTRICT:								
Above Burgess Picnic Ground	180	170	3.3	0.4	.45	14	64	.21:1
Below Burgess Picnic Ground	170	172	3.3	0.3	.79	14	41	.44:1
Above Spear-O-Wigwam	13	30	0.0	0.2	.14	44	4	11:1
Below Spear-O-Wigwam	13	30	0.8	0.1	3.5	261	44	5.93:1
Above Bear Lodge	170	194	7.4	1.0	.49	25	22	1.13:1
Below Bear Lodge	180	190	6.6	0.2	1.1	73	55	1.32:1
Above Arrowhead Lodge	130	146	2.5	3.5	.79	14	5	2.8:1
Below Arrowhead Lodge	130	146	2.5	0.2	3.5	172	315	.54:1
BUFFALO DISTRICT:								
Above Johnson Co. Day Camp	15	36	0.0	0.1	5.4	43	113	.38:1
Below Johnson Co. Day Camp	15	30	0.0	0.1	1.6	226	153	1.47:1
Above So. Fork Inn	13	36	0.0	0.6	.49	2	62	.03:1
Below So. Fork Inn	13	36	0.0	0.6	.33	4	81	.04:1
Above Pines Lodge	18	36	0.8	0.1	1.3	25	88	.28:1
Below Pines Lodge	15	34	0.0	0.2	2.8	19	94	.20:1

Source: Water Quality Management Considerations, Forested Lands Areas, Northeastern Wyoming, Water Resources Research Institute, p. 29.

Table 47 summarizes fecal coliform concentrations measured by the Forest Service near recreational areas on forested lands.

TABLE 47

Fecal Coliform Concentration Related to Recreational Areas

Concentrations Per 100 ML Samples

Site	No. of Samples	No. of Fecal Coliform Occurrences	No. of Excesses ≥ 200 colonies/100 ml
Marcum Ck.	14	14	3
Little Willow Ck.	18	18	0
South Tongue R.	3	3	0
Owen Ck.	4	4	0
Prune Ck.	4	4	0
Middle Clear Ck.	7	7	0
North Clear Ck.	5	3	0
South Clear Ck.	10	10	0
Clear Ck.	9	8	0
Powder at Kaycee	26	26	4
Sibley Res.	8	4	0
Rock Ck.	8	8	2
Little Bighorn	4	4	0
Tongue	26	19	1
Little Goose	9	8	0
W.F. Big Goose	5	4	0
N. Piney	4	3	1

Source: Water Quality Management Considerations, Forested Lands Areas, Northeastern Wyoming, Water Resources Research Institute, p. 30.

With increased population growth in the three counties, additional accommodations for recreationists can be projected, along with increased wilderness activity and increased hunting and fishing activities. Recent wilderness impact studies have indicated that domestic animals and population concentrations have minimal effect on bacteriological contamination, but usage concentration increases may contribute to future problems. Limiting access into heavily used areas could assist in the control of concentration of distinguishable point sources. Specifying distance limits for camping near streams may require enforcement to prevent sewage interception by streams.

Local erosion problems could occur on the forested lands, particularly on trails. Due to the geological nature of the soil, depth of the soil bank and limited groundcover in certain areas, land disturbance from off-road vehicles often combines with livestock and nature, resulting in meadow rutting and hillside gullying. Areas throughout the Bighorn Mountains are scarred from such disturbances. Certain areas are capable of natural rehabilitation if erosion potential is minimized.

Suggested Management Guidelines

Suggested management guidelines related to recreation are concerned with erosion control, water chemistry and bacteriological contamination:

1. Continue bacteriological monitoring above and below resorts, summer home groups and heavy use areas. Concentrated and consistent sampling could provide valid data to aid in installation of adequate facilities to minimize contamination.
2. Enforce off-road driving laws and restrict camping in undeveloped areas. These measures could reduce potential land disturbance and possible bacterial injection into streams.
3. Continue environmental conservation programs to educate the public. The Environmental Education Workshops offered by the Forest Service, for example, have stimulated public awareness of conservation problems and their prevention.
4. Utilize sound engineering practices when constructing facilities and access roads. It is also necessary to insure nonerosive velocities and grades, and to scarify or harden existing sites as necessary.
5. Maintain buffer or filtration zones between facilities and streams. Such zones could further reduce sediment erosion potential in susceptible areas.

Silviculture

Pollution Assessment

Silviculture has been interpreted by the Environmental Protection Agency as defining all forest management activities. The major timber harvest areas in the three counties are managed by the Forest Service and are located on Map 9 following page 26.

Other areas, however, also offer the potential for economically sound timber harvests.

Proper land management practices and activities must comply with standards established for individual site inspections generally compiled by the Environmental Protection Agency.

The Bureau of Land Management is initiating large-scale timber harvest programs in the southern Bighorn Range following basic management criteria for sustained yield and continuation of multiple-use programs as practiced by the Forest Service. The Bureau of Land Management and state efforts are contained in their similar Management Framework Plans (MFP). The State Forestry Division has conducted timber harvesting in the southern Bighorn for the past 20 years and multiple-use programs and harvests will continue on state lands under sustained yield resource management plans.

The Forest Service has classified the Bighorn National Forest by land use areas for timber management. Approximately 68 percent of the land mass is suitable for timber harvest, while only 21 percent is ideally feasible for immediate development.

Federal and state management programs are designed to provide quality timber, improve the landscape, expand recreational possibilities, conserve the watershed and improve range forage. Preharvest planning includes soil surveys and hydrologic determinations, silviculture analysis, range evaluation and road engineering analyses. Timber stands are inventoried and evaluated to determine the economic and environmental feasibility of a proposed timber sale.

Generally, sedimentation, chemical alteration and debris accumulation are considered the main pollutant sources originating directly from timber removal. The major impact from timber harvest is generally increased erosion or sedimentation resulting from increased runoff. In the three-county area spring runoff is attributed to snowmelt. Snowmelt, i.e., runoff, generally occurs earlier in harvest areas due to increased sunlight exposure attributed to canopy removal. This results in slightly earlier peak flow (some streams peak 5 to 7 days earlier). However, peak runoff generally does not appreciably increase, but high water is extended over a longer period of time. This implies that less water is available for percolation and interflow. However, significantly higher increases in sediment have not been observed following timber harvests in the Bighorn National Forest.

Sediment loads and dissolved nutrients in surface runoff and possibly in streams could increase due to runoff in harvested areas. In the Big Horn National Forest, runoff is not expected to change significantly as a result of timber harvest. A study conducted by the U.S. Forest Service on Prune Creek in the Tongue River drainage reached the conclusions that:

1. The reduction in interception loss (plant absoption of moisture) from thinning was compensated for by increased evaporation from the snow surface.
2. A 50 percent canopy reduction would not significantly reduce the amount of water utilized by the remaining forest.
3. The effect of water yield and snowmelt timing when select cutting is employed is not large.

Many factors influence erosion including depth of soil, slope gradient, vegetation cover, soil disturbance, soil structure and the impact of raindrops. Soil characteristics of the Bighorn Mountains are such that infiltration or moisture absorption is reduced where excessive soil disturbance takes place.

As a general rule, if there is less compaction and disturbing contact with the forest floor, there is less watershed damage resulting from logging and skidding operations. Table 48 compares possible tendencies for on-site erosion before and after clearcutting of timber. Interpretation of this table indicates slope, ground cover and ground disturbance are signigicant to sediment quantity.

Timber areas that have been harvested can be susceptible to surface erosion due to the compacting action of heavy equipment used in logging operations. Normally, absorbent soils lose their ability to infiltrate water when compacted. Roads and trails tend to accelerate erosion due to

TABLE 48

Estimated On-Site Erosion Before and After Clearcutting[1]

Slope %	Estimated Total Ground Cover Before Harvest	Estimated On-Site Erosion		Estimated Total Ground Cover Following Timber Harvest & Treated w/Rolling Chopper	Estimated On-Site Erosion		Estimated Total Ground Cover Following Timber Harvest & Dozer Piling	Estimated On-Site Erosion	
		Tons/ac /yr	Inches/ ac/yr		Tons/ac /yr	Inches/ ac/yr		Tons/ac /yr	Inches/ ac/yr
GRANITIC SOILS:									
10	70	0.4	0.0026	70	0.4	0.0026	50	1.0	0.0064
20	70	0.9	0.0058	70	0.9	0.0058	50	2.1	0.0134
30	70	1.3	0.0083	70	1.3	0.0083	50	3.0	0.0192
40	70	1.6	0.0102	70	1.6	0.0102	50	4.0	0.0256
SOILS DEVELOPING IN FINER TEXTURED IGNEOUS AND METAMORPHIC BEDROCK:									
10	85	0.2	0.0013	75	0.4	0.0026	70	0.4	0.0026
20	85	0.5	0.0032	75	0.8	0.0051	70	0.9	0.0058
30	85	0.7	0.0045	75	1.1	0.0070	70	1.4	0.0090
40	85	0.9	0.0058	75	1.4	0.0090	70	1.8	0.0116

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[1] May or may not reach live water depending on a variety of conditions.

Source: Water Quality Management Considerations, Forested Lands Areas, Northeastern Wyoming, Water Resources Research Institute, p. 39.

the general increase of slope gradient on cut and fill slopes, collection of overland flow on the road surface and, in some cases, interception of subsurface springs crossing cut areas. Mass erosion potential increases as seasonal or excessive hydrologic factors contribute to the erosive process.

Logging near surface waters exposes part of an area to increased sunlight, resulting in higher water temperature and increased algae growth. The chance for organic debris entering stream channels is also increased, resulting in higher bank erosion, channel alterations, leaching of toxic compounds, biodegradation of organic matter and reduction of dissolved oxygen levels.

Physical deposits of organic materials on stream bottoms may affect bottom habitat and aquatic life. Change in water color, taste, chemical composition and odor may also occur.

Revegetation is important to establish soil stability in harvest areas. Where soils are particularly subject to disturbance, ground cover regeneration is necessary immediately. Road and trail rehabilitation includes reseeding cross drainage construction, contour ditching and restoring roads to the natural ground contour.

Suggested Management Guidelines

Recommended management guidelines related to silviculture include the following suggestions:

1. Maintain adequate filtration and buffer zones along streams to minimize interference with fish and aquatic life to reduce the deposition of dissolved organic and inorganic materials in the riparian zone, and to aid in maintaining consistent natural water temperature vital to aquatic life.
2. Revegetate harvest areas quickly with soil holding vegetation. Prompt vegetation of exposed soil may reduce erosion potential.
3. Fall trees and skid parallel to slope contours in an effort to reduce slope disturbance.
4. Monitor pertinent locations above and below harvest areas for sediment, discharge and water chemistry.

5. Liberally construct waterbars, diversion ditches and sediment traps. Such features can minimize surface erosion on skid trails and reduce massive soil movement from cut and fill slopes on access roads.
6. Remove slash from draws and stream channels where there is high potential from channel erosion.
7. Collect chemical and oils from equipment maintenance.
8. Follow sound engineering and construction practices for trails and roads.
9. Cross-contour landings, trails and roads by scarification and utilizing mulches and fertilizers; utilize reversal ditches and velocity controls to overland flow and sediment.
10. Minimize soil compaction from equipment by limiting activity to dry or frozen areas.
11. Plan roads and trails efficiently.
12. Restrict equipment operation to slopes of 35 percent or less.
13. Utilize practical harvest methods for individual areas. Logging in unstable areas should be limited to methods which do not disturb duff or upper organic layer.
14. Follow tops and south-facing ridges when practical for trails and roads.
15. Stockpile topsoil for later use when constructing roads.
16. Select proper plant species for revegetation programs.
17. Restrict activity in the area until production-recovery has stabilized.
18. Continue to require special permits for rock crushing, gravel washing, log sorting and log storage, with operations being responsible for water quality limits.
19. Monitor suspended sediment, stream flow variations, chemical composition and erosive patterns before and after timber harvesting to determine the effectiveness of management practices.

Livestock and Wildlife Management

Pollution Assessment

Forested lands in the three-county area provide summer range (July, August and September) for thousands of cattle and sheep. At least 194 livestock grazing permits are issued each year on national forest land for a total of approximately 32,000 cattle and 52,000 sheep. The major grazing areas on federal forested lands are shown on Map 10 following page 27.

Competition for range and habitat among elk, deer, moose, bighorn sheep, cattle and domestic sheep presents problems of migration, forage, distribution and grazing.

Bacteriological contamination from wildlife and livestock wastes is a major concern in the Big Horn watershed. Distribution of wildlife and livestock presents bacteriological problems. Livestock concentrate near riparian zones of streams and lakes since food supplies are generally found in these areas. Livestock concentrations in particular drainage basins at certain times of the year may contribute to the concentration of bacteria in streams. In late June and early July, concentrations are generally rising. August and September bacteria concentrations also are high possibly due to the distribution of livestock herds during roundup.

Table 49 shows fecal coliform concentration related to the seasonal influx of animals, particularly livestock, on forested lands.

TABLE 49

Historical Water Quality Considerations:
Grazing Practices, Bighorn National Forest

Drainage Areas	Season	Approximate Number of Samples	Number of Fecal Coliform Occurrences	Excesses of 200 colonies/ 100 ml
Big Willow Little Willow North Tongue	Spring	15	15	0
	Fall	15	15	1
Sibley Marcum South Tongue	Spring	10	10	2
	Fall	10	6	1
West Fork Big Goose Big Goose Little Goose	Spring	11	10	1
	Fall	11	9	0
North Piney Rock Clear	Spring	21	20	1
	Fall	21	19	2

Inconsistency and lack of valid data indicates further investigation is necessary for justifiable conclusions to be made.

Source: Water Quality Management Considerations, Forested Lands Areas, Northeastern Wyoming, Water Resources Research Institute, p. 46.

Desirable areas for grazing are susceptible to eventual degradation. Riparian zones along streams, particularly, are easily overgrazed, or soil compaction on trails and banks occurs. Erosive action by water could be increased due to lack of ground cover and increased overland flow of water. Areas around stock ponds, salting sites, bedding grounds, fence lines and stock driveways are often heavily compacted due to the concentration of animals year after year. Heavy runoff or overland flow makes these areas highly susceptible to sedimentation, gullying and slope change.

Range improvement by use of controlled burning and herbicide and pesticide treatment may present minor water quality problems depending on location and soil characteristics.

Suggested Management Guidelines

The following management guidelines related to wildlife and livestock are centered around soil compaction, trail erosion and bacteriological contaimination:

1. Maintain adequate monitoring programs. Continuous and consistent stream monitoring is recommended.
2. Distribute herds evenly and redistribute at pertinent intervals to avoid concentrations and overgrazing. Frequent redistribution of herds to new areas may reduce concentrated use along riparian zones and minimize waste injection directly into streams.
3. Select locations for salting sites, fences and driveways carefully to avoid constant compaction.
4. Utilize waterbars or diversion facilities on existing trails and driveways to avoid future erosion problems.
5. Fence and cattleguard recreational facilities.
6. Enforce existing regulations related to herd size, distribution, and grazing time.
7. The need for potable water for domestic use may require necessary closure of the drainage area to grazing.

Mineral Development

Pollution Assessment

Full-scale mineral development on forested lands in the study area has not taken place due to location of profitable deposits in other areas with easier access. The approximate locations of active and non-active mineral development sites near forested regions are shown on Map 11 following page 28.

Favorable deposits of industrial materials such as bentonite, gypsum, and high-calcium limestone are sited along the eastern flanks of the Big Horn Range and throughout southwestern Johnson County as reported by the Wyoming Geological Survey. Mining operations are under development at isolated sites and proposals for mining along the flanks of the Big Horns are being considered by private construction and industrial groups.

Water quality may be affected by increased total dissolved solids, hardness change or sedimentation from underground mining of high-calcium limestone. Economic and geological factors affect the ability to extract this mineral due to the outcropping characteristics of the producing formation.

Bentonite and gypsum pit mining has yet to establish itself on forested lands due to the quality of materials available elsewhere. Some mining operations are spreading by small pits along the southern face of the Big Horn Range. Local erosion due to land disturbance has been isolated and minimal in most cases.

Construction materials are readily available in most areas of the forested lands in the Big Horn Range. Economics and availability of suitable materials govern the location of crushing sites and borrow pits. Road development and maintenance utilize most of the materials in the form of gravel, base material and sands with resulting major physical damage to the landscape.

Small deposits of gold, uranium, copper, manganese and rare earth metals are found in forested areas. Several small gold mines have been abandoned which have had little impact on the watershed. Numerous exploratory locations for uranium in southwestern Johnson County have not produced deposits suitable for large commercial development at this time. Exploration for petroleum and coal has not indicated the presence of commercially developable deposits at this time on forested lands.

Future development of various mineral deposits could be economically feasible especially for construction and industrial materials. Most of the deposits lie along the flanks of the Bighorn Mountains and could create isolated erosion problems. Development of these materials should be preceded by a careful site evaluation. In the end result, sediments and dissolved solids may be the main pollution source related to mineral developments.

Suggested Management Guidelines

Recommended guidelines include:

1. Installation of adequate drainage facilities such as diversion ditches, waterbars and reversal ditches.
2. Monitoring water quality before and during development activity. Chemical alterations from limestones and other sedimentary minerals could create future problems if runoff and stream exposure is not diverted away from susceptible areas.
3. Contouring, revegetation and reclamation of the area to a state equal to or better than the original state.
4. Future management plans should include revegetative and adequate drainage facilities to minimize sedimentation and reduce direct leaching action through stockpiles or exposed areas into stream channels, thus minimizing or eliminating chemical alterations of the water.

Transportation Development[1]

Pollution Assessment

Major highways and improved roads are susceptible to various types of problems related to water quality. Sedimentation should be carefully considered in development of slope gradients, culverts, right-of-ways, cuts and fills, and borrow pits. Revegetation and stabilization of topsoil should be established as soon as possible after disturbances. Stream channel disturbance for crossings and bridge construction produces sedimentation but is generally not a continuing problem. Chemical and petroleum waste drainage into streams could create problems with the aquatic habitat if not properly controlled.

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[1] Please refer to p. 187 concerning the State-wide Highway and Road Construction Assessment process for additional information.

Most unimproved roads in the Bighorn Range were originally constructed for livestock, recreational and logging purposes, but many are now utilized seasonally by camping parties, hunters and livestock. The major problem associated with unimproved roads is recreational misuse where a combination of moisture, soil type, ground cover and vehicles compound the initial ground disturbance. Natural erosion proceeds as new exposures are created.

Road closure evaluations are conducted by state and federal agencies considering existing erosion and future potential, economic factors for maintenance or reconstruction, usage, road necessity, public safety, sediment traps and diversion possibilities and public opinion.

Various public utility routes cross portions of forested lands in the study area. Land disturbance is the major problem resulting from construction of utility lines. Petroleum pipelines are located along the eastern flanks of the Bighorns and throughout Campbell County. Only isolated timber stands in northern Campbell County are potentially susceptible to petroleum spillage, resulting in eventual water quality degradation.

Major emphasis should be given to reduce erosion of roads and trails built to facilitate logging or other forest uses.

Suggested Management Guidelines

Pollution related to transportation development can be minimized by relating the following best management guidelines to construction and engineering projects:

1. Sound engineering and construction practices could reduce impact on the watershed due to degeneration of materials and sedimentation.
2. Careful surveillance of slope gradient, geologic formations, water sources, ground cover and drainage characteristics could reduce future maintenance problems.

3. Revegetation of road side slopes, buried line routes and abandoned roads and trails could be enhanced by scarification, contouring, mulching and fertilizer application. Revegetation of slide slopes and closed roads is recommended to help stabilize the topsoils.
4. Staggering utility line routes through forested areas provides greater aesthetic beauty for the area and could reduce trenching. Utility lines and facilities should be revegetated to help stabilize topsoil.
5. Sound road construction practice should provide excellent access with minimal maintenance.

Fire and Post-Fire Management

Pollution Assessment

Fire control, rehabilitation and recovery is a major part of the forest conservation program. Many components of the forest are affected by fire, including soils, streams, vegetation, wildlife and downstream facilities.

Forest burned areas may provide residue and chemical sources for water quality degradation. Generally, burn areas are small in the Big Horns in comparison to watershed size so nitrate and phosphate release is diluted into background levels. Nitrogen in particular is reintroduced into an area by leguminosae plants which are usually first to revegetate after a burn. Losses in a fire can generally be considered short-term depending on intensity of the burn, soil types, reseeding or regeneration potential, and leaching potentials.

After a fire, erosion susceptibility in isolated areas may be high due to destruction of the ground cover. Access roads may be constructed in a salvage area; therefore, the timber sale contract water quality clauses should be followed to minimize sedimentation potential and hasten soil stability through revegetation programs. Progressive erosive potential is evaluated at intervals to detect problems so necessary preventive measures can be immediately initiated to reduce extensive erosion conditions.

Forest fires have played an important role in natural regeneration and maintenance of preferred tree species. Controlled burnings in certain areas are necessary and economically feasible. Studies concerning the watershed impacts of fire on the Teton-Bridger National Forest were conducted to compare spring versus fall burning. In the spring, soils were cooler,containing more moisture, and minor effects on grasses and herbaceous vegetation were noted from spring burning. By contrast, fall burning occurred under drier conditions, fires burned hotter and vegetation recovery was slowed by 1 to 3 years. The difference in vegetation recovery may be explained by the fact that various growth and food storage portions of the plants are protected in the spring; therefore, recovery of ground cover is faster. The following year nitrate and phosphate levels increased below the fall burn area due to hot burning during a drier period.

Most forest fires occur in late summer and early fall in the three-county area, when dryness and increased usage increase fire hazards. Residue and slash burning from timber harvest increase the possibility of watershed pollution.

Controlled burning of slash piles resulting from timber harvest generally occurs after sufficient snow cover is accumulated in the fall or winter. Specific burn spots contain concentrations of ash residues, and subsoil becomes crusted due to heat. Generally, minimal adverse conditions are experienced at these burn sites due to winter conditions and swift revegetation of grasses in the spring.

Some wildfires require aerial application of fire-retardant chemicals. No certain documentation indicates adverse effects from fire retardants on water quality, but it is apparent that the reaction of the retardants in nitrate and ammonia concentrations could occur in streams or lakes. Drop zones usually occur away from live and standing water.

Suggested Management Guidelines

Suggested management guidelines for fire and post-fire management include the following:

1. Evaluate the physical conditions of burned areas related to the original conditions, i.e., soils, hydrology, available range and recovery potential. Fire management can be aided by soil, hydrologic and range evaluations.
2. Install preventive erosion measures if needed, such as waterbars on firelines, sediment traps in gullies and diversion facilities.

3. Fertilize and revegetate the area with fast-growing but desirable plant species for surface stabilization. Fast and reliable implementation of revegetation programs minimizes long-term consequences related to fire.
4. Include frequent water chemistry, sediment and discharge analyses as part of the physical-hydrologic evaluation in support of favorable management programs.
5. Apply slurry (fire retardant chemicals) at or near crests of ridges, avoiding streams and lakes when possible.

Forested Lands Program

Future social, economic and ecological developments in the Powder River Basin will be dependent on population growth. A balance between utilization of forested lands and desirable habitat will eventually be needed to favorably conserve and protect renewable natural resources in the forested areas. The existence of quality water is part of the environmental cycle necessary for preservation of the natural habitat. Future management and planning efforts will be centered around Federal Unit Plans and State Management Programs specific to the particular agency.

These plans and programs are the responsibility of the United States Forest Service, Bureau of Land Management, Wyoming State Forestry Division and private interests. The United States Forest Service and the State Department of Environmental Quality also review construction of individual disposal systems on U.S. Forest Service lands. The Department of Environmental Quality and the Environmental Protection Agency provide standard criteria for the agencies mentioned above to implement agency plans and programs.

The following list contains a review of recommended management guidelines which contain site specific recommendations in some instances. However, this list contains practices which are more program oriented which serves as an overall guide.

Recreation[1]

1. Enforce existing regulations.
2. Provide sufficient and efficient facilities.
3. Develop educational conservation programs for the public.
4. Undertake careful site selection.
5. Conduct comprehensive and consistent physical and hydrological monitoring of streams and facilities.

Silviculture

1. Supervise and enforce timber sale contract water quality and physical parameter preservation clauses.
2. Maintain buffer zones for temperature stabilization, sedimentation, debris traps and habitat security.
3. Utilize correct harvest methods and equipment for given areas.
4. Use good road construction and trail practices and construct on stable land.
5. Clear slash from gullys and draws; burn in piles or spread where necessary for decay.
6. Utilize seasonal factors, i.e., frozen ground or dry areas when feasible.
7. Revegetate abandoned roads, landings and trails.
8. Conduct comprehensive water quality and quantity analyses.

Livestock and Wildlife

1. Follow range and hydrologic evaluations.
2. Distribute and limit herds to prevent concentrations.
3. Fence and utilize cattleguards around campgrounds and other recreational facilities.
4. Selectively determine salting, fencing and access sites to reduce erosion and compaction.
5. Continue bacteriological and physical observation of continuous livestock usage areas.
6. Enhance habitats by evaluating overmature areas for possible rehabilitation.

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[1] Local and state recreation agencies and the Wyoming Recreation Commission should be involved in the continuing water quality management program.

Mineral Development

1. Plan physical, chemical and hydrological monitoring programs.
2. Utilize conservative extraction means.
3. Contour sites to favorable conditions.
4. Revegetate with suitable plant species.

Transportation Development

1. Adequate planning for roads, utility rights-of-ways and sewage systems.
2. Plan physical, chemical and hydrological monitoring programs.
3. Utilize soils and hydrological evaluation.
4. Utilize conservative construction practices on slopes and stream crossings and revegetate vital areas.
5. Stagger routes to enhance the aesthetic appeal of the area.

Fire

1. Utilize solid and hydrologic evaluation.
2. Revegetate if necessary.
3. Provide sediment traps, waterbars or diversion facilities to prevent downstream and hillside damage.
4. Follow timber sale contract water quality clauses if salvage timber is available.
5. Utilize sound construction practices if roads are built.
6. Conduct water quality, sedimentation and physical analyses regularly to isolate possible problems and help speed recovery.

SALINITY ASSESSMENT

Introduction

Chapter II of this document described the instream salinity increases observed in drainages throughout the PRAPO planning area. The proposed Water Quality Standards recognize the potential severity of increasing salt loads in the State's rivers and streams. Within the PRAPO planning area, the following stream segments record potential salinity problems: Prairie Dog Creek, Powder River, Clear Creek, Crazy Woman Creek, Salt Creek and South Fork Powder River.

Pollution Assessment

Although limited data were available to describe the water quality in Prairie Dog Creek, it appears as if the most potentially severe water quality problem is salinity present in the lower reaches of the drainage. The concentrations observed caused sharp increases in the salinity levels of the mainstem of the Tongue River below the Prairie Dog Creek Confluence. Sources of salinity in this drainage are primarily natural in origin. Piney Creek waters diverted into the drainage for irrigation use may have a dilution effect on the natural salinity levels.

Salinity in the Powder River is essentially a function of the salinity contributions of its tributaries. The contributions of Salt Creek and South Fork cause the mainstem concentration to increase while Crazy Woman Creek and Clear Creek contributions have the opposite effect.

Mean salinity concentrations in Clear Creek are below 700 mg/1. However, occasional peaks during late summer months reach levels which may prove detrimental to irrigation use if prolonged over extended periods of time. Irrigation exists throughout the entire length of the drainage and could possibly contribute up to 28 percent of the salinity load during the irrigation season.

Salinity concentrations on Crazy Woman Creek average over 1100 mg/1. Upper reaches of the drainage, near the confluence of the forks, contain 25 percent to 40 percent saline and alkaline soils. This area also contains most of the irrigated lands in the drainage. A possible 26 percent of the salinity load during the irrigation season may be caused by irrigation.

Salt Creek provides 26 percent of the total salt load in the Powder River at the State line. Except during runoff periods, the entire salt load in the creek is attributable to point source discharges from oil well treaters. Irrigation is almost non-existent in the drainage.

South Fork Powder River has very high salinity concentrations which are primarily attributable to saline geology and soils. Point source discharges account for about 14 percent of the salt load in the drainage. Irrigation use of the waters is negligible.

Neither the salinity levels in the Tongue River drainage nor the salinity levels in the Powder River drainage appear to be presently affecting the beneficial uses of the waters in Wyoming. In both the lower Tongue River drainage and the Powder River drainage, irrigation is the most restrictive use of the water. Local conservation district personnel and Soil Conservation Service personnel have indicated that salinity concentrations in waters used for irrigation have not reached a level where salt buildup is occurring in irrigated soils. Also, the predominant irrigated crops in the area, alfalfa, hay and grains, have relatively high salinity tolerances. An irrigation salinity study completed by the Yellowstone-Tongue 208 agency in Montana indicated that generally salinity levels in the Powder River were not affecting crop yields as of this time.

Salinity Management Programs

In instituting any management program, a need for that program must first exist. That need is dependent upon whether beneficial uses of the water are being impaired or the quality of the water is approaching the point where impairment is predicted. Although this has not been a comprehensive salinity study, from analysis of the available data and information from those people who would be most affected (agricultural people) it appears no need exists at the present time for a formal salinity management program in either the Tongue River drainage or the Powder River drainage.

However, this does not take into consideration the effect that future development in these drainages may have. If the need for control programs does exist in the future, four general types of management programs are available to control salinity in these and other drainages; they include:

1. Implementation of on-site control programs for new development in the drainage.
2. Implementation of retroactive on-site control program for existing land uses in the drainage.
3. Establish salt allocation systems where an allowable basin-wide loading is determined.
4. Decrease salt discharge to a drainage by consumptive use of all or part of a tributary flow or flows.

Along the Powder River mainstem, little irrigation occurs downstream of the Sussex Irrigation District because of topographic restrictions. In the future if these restrictions can be overcome and irrigated lands are developed in that area, it will be necessary to institute salinity control programs which would reduce the Powder River salinity levels between Sussex and the Clear Creek confluence. The single source category which contributes mainly to salinity levels in that segment of the Powder River is discharges from oil well treaters on Salt Creek. This source is also the most receptive to control measures in the drainage. Complete elimination of oil well point source discharges into Salt Creek would reduce mean salinity levels in the Powder River at Arvada from 2009 mg/1. to 930 mg/1. A second alternative of placing more restrictive effluent limitations on these discharges to reduce the salinity load by 50 percent, while not reducing the amount of water discharged, would reduce the mean Powder River salinity level at Arvada to approximately 990 mg/1.

Future development on the Tongue River is a greater possibility than on the Powder River. A number of coal mining operations as well as large power generating plant are now being considered for the drainage. Existing data on coal mine discharges indicate that individual mines probably would not have a significant effect on salinity levels in the drainage, however the cumulative effect of a number of mines may cause a noticeable increase in salinity levels. If a power generating plant were to be constructed on

Prairie Dog Creek, as presently being considered, and its waters used for cooling and steam generation, the consumptive use of those waters would increase the already high salinity concentration of Prairie Dog Creek. The combined effect of the mine discharges and the power plant discharge entering the Tongue River could have a significant effect on Tongue River salinity levels. If levels are increased to the point where use impairment is a possibility, the need for on-site control programs for the new developments or the establishment of a salt load allocation system in the drainage may exist.

The possible need for these control measures are all dependent on future development in the drainage. At present, there is no need for control action to protect beneficial uses of the waters. Consideration must be given, however, to the proposed changes in Montana's stream classification system and water quality standards. If adopted, the proposed changes would classify the Tongue River as a raw drinking water source. The instream total dissolved solids standard for the river would be set consummate with that use. Efforts may then be undertaken by Montana to force Wyoming to meet these standards at the State line. If successful, the need for salinity control actions on the Wyoming portion of the Tongue River would become immediate, since the mean salinity level on the Tongue River at the State line is now approximately 500 mg/1.

The implementation and regulation of specific program outputs is relegated to those existing agencies with mandated control over related programs or activities. However, no single agency at the state, federal, county or local level controls all of the required areas of a salt management program.

Implementation of specific control programs should be left to those agencies with mandated responsibility. Irrigation programs would be implemented by the local Conservation Districts with technical assistance from the Soil Conservation Service and Soil Conservation Commission. Water resource program controls will be implemented by the State Engineer's Office and the Board of Control and the Water Quality Division of the Department of Environmental Quality. Salinity occurring from mining activities would be controlled by the Land and Water Quality Divisions of the Department of Environmental Quality at the state level and by the Bureau of Land Management and United States Geological Survey at the federal level.

URBAN RUNOFF ASSESSMENT

Introduction

This section presents urban storm runoff chemical data collected from Sheridan, Buffalo and Gillette in an effort to identify adverse water quality effects to the receiving streams from urban storm runoff. The data were analyzed by comparing data collected by the Water Resources Research Institute during periods of non-storm runoff with data collected during runoff events.

Because of the relative size of the urban areas being considered, as well as the limited amounts of time, manpower and funding available for this work element, it was given a low priority within the total program. The most visible problem related to urban runoff occurs in the late winter and early spring. During the winter months, public works crews in the cities apply large amounts of sand or scoria material, mixed with de-icing chemcials, to the city streets for safety purposes. Over a long winter period, large amounts of this material accumulates on the streets and in the snow removed from the streets. In the case of Sheridan, this snow is piled along the stream banks of Little Goose Creek and Big Goose Creek. In the late winter or early spring, rising daytime temperatures cause the accumulated snow and ice in the cities to melt, carrying with it large quantities of road de-icing material. Public interest in the problem has been vocal and for that reason the work element centered around it. Due to the above mentioned limitations, no attempt was made to do a complete urban runoff study. As future funding for water quality planning becomes available in Wyoming, a more thorough approach for urban runoff assessment should be undertaken in the three cities.

General Characteristics of Urban Runoff

Storm discharges must be considered in terms of their shock-loading effects on receiving streams. A total of 94 to 99 percent of the organic load and almost all settleable solids in such streams are attributed to wet weather flow. Storm wastewater has been characterized by the Environmental Protection Agency as having solids concentrations equal to or greater than those of secondary effluent.

The sources of stormwater pollution are many and mixed, and are a function of factors such as land use, geography, weather, traffic volumes and character, and local public works factors. However, most stormwater pollution is considered as street surface contamination, which is comprised primarily of particulate matter but also can include non-particulate soluble and suspendable matter. Among the sources of street surface contamination are the following:

Pavement

Pavement contaminants consist of asphaltic and portland cement, their various products of decomposition, aggregate materials, small amounts of road marking paints and crack fillers. The rate of generation of these types of pollutants depends on the age and condition of street surfaces, the local climate, and leaks and spills of solvents which aid in degradation of asphaltic pavements.

Motor Vehicles

A broad range of street surface contaminants can be attributed to the automobile, including:

1. Leakage of fuel and lubricants;
2. Fine particles worn off tires;
3. Particulate exhaust emissions and leaded compounds. Sulfur compounds removed by catalytic converters may combine with water and produce sulfuric acid;
4. Dirt, rust, and paint coatings which drop off motor vehicles;
5. Glass, plastic, and metals which are deposited on streets after collisions.

These types of materials vary in their potential as harmful water pollutants. Fuels and lubricants increase inorganic loadings, and also cause films which hinder oxygenation. Most fuels contain lead, nickel, and zinc compounds which may be harmful to biological forms.

Vegetation

Leaves, bark, grasses, etc., which collect on the street or are purposefully placed there are important as water pollutants because they contribute to the biochemical oxygen demand when entering surface streams. The demand may be immediate if they accumulate in catch basins or long-term if the organic materials become a benthic deposit. Nutrients and pesticides are also associated with vegetation.

Runoff from Adjacent Land Areas

The major violators in this category are construction projects which increase the erosion process by stripping vegetation that would usually detain and reduce the velocity of runoff water.

Sheridan

Climate

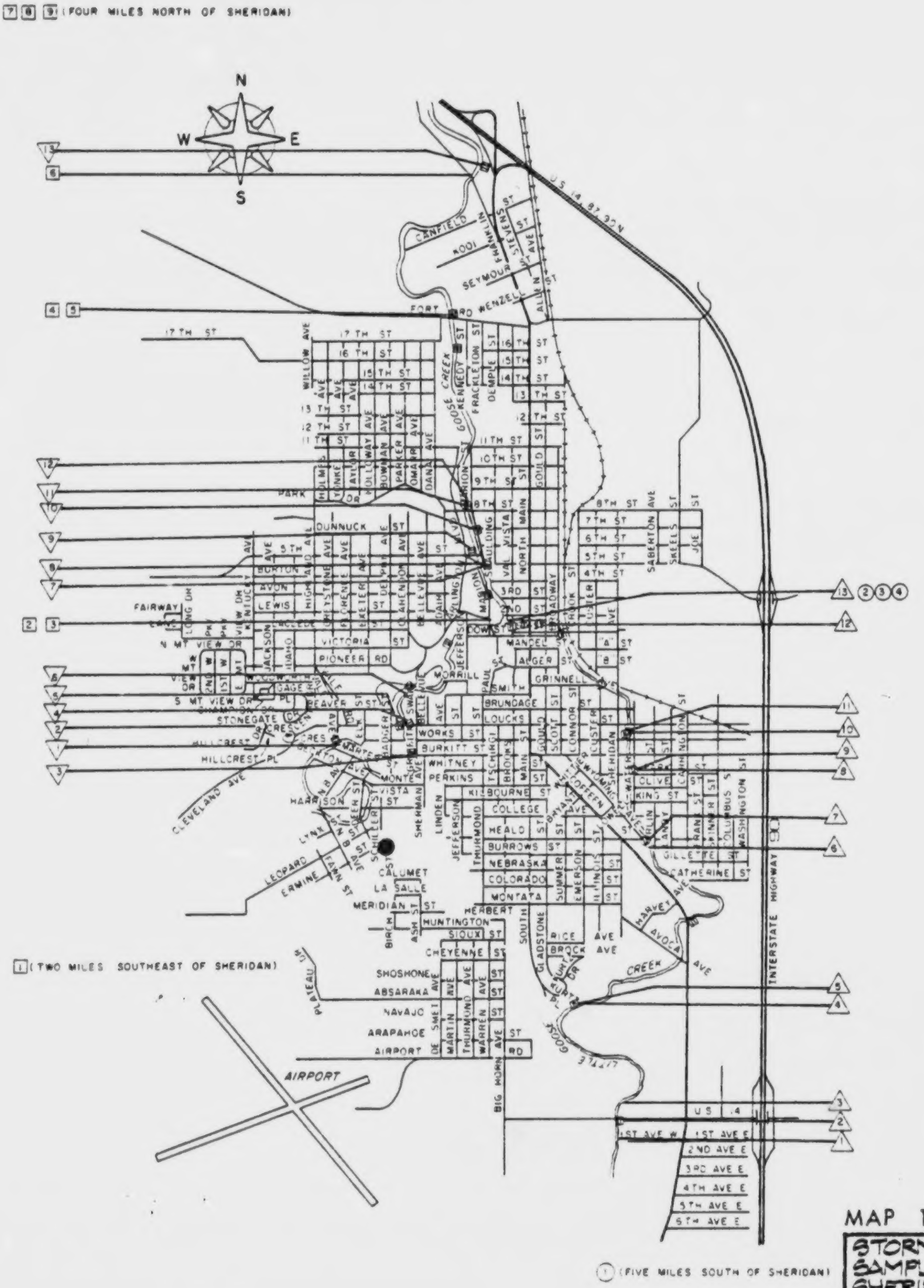
The average annual precipitation in Sheridan amounts to 16 inches. Total precipitation is divided fairly evenly between rain and snow with average annual snowfall amounting to 69 inches. The coldest month is January, maintaining an average daily maximum temperature of 33.5 degrees and an average daily minimum temperature of 21 degrees. The warmest month is July, with an average daily maximum temperature of 86.1 degrees and an average daily minimum temperature of 70.4 degrees. A summary of the mean monthly precipitation for Sheridan appears in Table 50.

TABLE 50

Mean Monthly Precipitation, Sheridan

Month	Precipitation (inches)	Month	Precipitation (inches)
January	.74	July	1.05
February	.77	August	.92
March	1.19	September	1.30
April	2.19	October	1.08
May	2.36	November	.89
June	2.85	December	.69

Source: Urban Runoff Study, Sheridan, Buffalo, and Gillette, Wyoming, Water Resources Research Institute, p. 6.


7 8 9 (FOUR MILES NORTH OF SHERIDAN)
N
W
E
S
U S 14 87 320 N
CANFIELD
KOOI
SEYMOUR
STEVENS
FRANKLIN
WENZELL
ALLEN
FORT RD
17 TH ST
WILLOW AVE
16 TH ST
15 TH ST
14 TH ST
13 TH ST
12 TH ST
11 TH ST
10 TH ST
9 TH ST
8 TH ST
7 TH ST
6 TH ST
5 TH ST
4 TH ST
3 RD ST
GOOSE CREEK
KENNEDY
FRACKLETON ST
HOLMES
YONKEE
TAYLOR
HOLLOWAY AVE
BOWMAN
PARKER AVE
OMAHA
DANA AVE
PARK
DUNNUCK ST
BURTON
AVON
LEWIS
FAIRWAY
LONG DR
N MT VIEW DR
S MT VIEW DR
JACKSON
IDAHO
VICTORIA ST
PIONEER RD
GOULD ST
MAIN ST
NORTH MAIN
VISTA
SPAULDING
BROADWAY
SABERTON AVE
SKEELS ST
JOE ST
MANDEL
ALGER ST
GRINNELL
SMITH
MORRILL
JEFFERSON
BRUNDAGE
LOUCKS
WORKS
BURKITT ST
WHITNEY
PERKINS
KILBOURNE
COLLEGE
HEALD
BURROWS ST
NEBRASKA
COLORADO
MONTANA
STONEGATE
HILLCREST DR
HILLCREST PL
CLEVELAND AVE
HARRISON
LYNX
LEOPARD
ERMINE
CALUMET
LA SALLE
MERIDIAN
HERBERT
HUNTINGTON
SIOUX ST
CHEYENNE ST
SHOSHONE
ABSARAKA
NAVAJO
ARAPAHOE
AIRPORT RD
DE SMET
MARTIN AVE
THURMOND AVE
WARREN AVE
BIG HORN AVE
SOUTH
GLADSTONE
RICE
BROCK
AVE
HARVEY
AVOCA AVE
CREEK
LITTLE GOOSE
PLATEAU
AIRPORT
LINDEN
SHERMAN
SCHILLER
SUMMER
EMERSON
ILLINOIS
CONNOR
SCOTT ST
CUSTER
COFFEEN
SHERIDAN
CLIVE
KING ST
CATHERINE ST
COLUMBUS
WASHINGTON
CANNINGTON
"A" ST
"B" ST
INTERSTATE HIGHWAY 90
US 14
1ST AVE W
1ST AVE E
2ND AVE E
3RD AVE E
4TH AVE E
5TH AVE E
6TH AVE E
1 (TWO MILES SOUTHEAST OF SHERIDAN)
1 (FIVE MILES SOUTH OF SHERIDAN)
13
6
4 5
12
11
10
9
8
7
2 3
6
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1
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13 2 3 4
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1

MAP 14

STORM DRAINS AND SAMPLE SITES SHERIDAN, WYOMING

- ■ - STORM DRAIN
- ③ - LITTLE GOOSE CREEK WATER QUALITY SAMPLE SITE
- △9 - LITTLE GOOSE RUNOFF SAMPLE SITE
- ☐2 - BIG GOOSE & GOOSE CREEK WATER QUALITY SAMPLE SITE
- ▽11 - BIG GOOSE & GOOSE CREEK RUNOFF SAMPLE SITE

Storm Drainage System

The present storm drainage system in Sheridan consists of surface and subsurface facilities and is described as inadequate, especially on the east side of the city. Identified needs include construction of flood-prevention structures in some areas, and adding curbs, gutters, and paving in unimproved areas to aid in surface drainage.

A total of 26 drains carry runoff into Goose Creek, 13 into Little Goose, 6 into Big Goose, and 7 drains carry runoff below the confluence of the two forks. The major drains are listed in Table 51 and shown on Map 14.

TABLE 51

Storm Drain Locations

Little Goose Creek	Big Goose Creek	Goose Creek
State Highway 334	Cleveland St.	Marion St.
Kurtz Place	Burkitt St.	5th St. (east side)
Coffeen Ave.	Loucks St. (west side)	5th St. (west side)
Heald St.	Loucks St. (east side)	7th St.
Park St.	Kendrick Park Rd. (south)	8th St.
Works St.	Kendrick Park Rd. (north)	16th St.
Custer St.		Fort Rd.
Scot St.		
Alley between Gould & Main Sts.		
Main St.		
Brooks St.		

Source: Urban Runoff Study, Sheridan, Buffalo, and Gillette, Wyoming, Water Resources Research Institute, p. 7.

Buffalo

Climate

Buffalo's climate is semiarid in nature. The mean annual precipitation is approximately 13 inches with the mean annual temperature amounting to approximately 46 degrees. Mean monthly precipitation figures for Buffalo appear in Table 52.

TABLE 52

Mean Monthly Precipitation, Buffalo

Month	Precipitation (inches)	Month	Precipitation (inches)
January	.63	July	.97
February	.57	August	.81
March	.75	September	1.25
April	1.86	October	.99
May	1.98	November	.72
June	2.67	December	.41

Source: Urban Runoff Study, Sheridan, Buffalo, and Gillette, Wyoming, Water Resources Research Institute, p. 7.

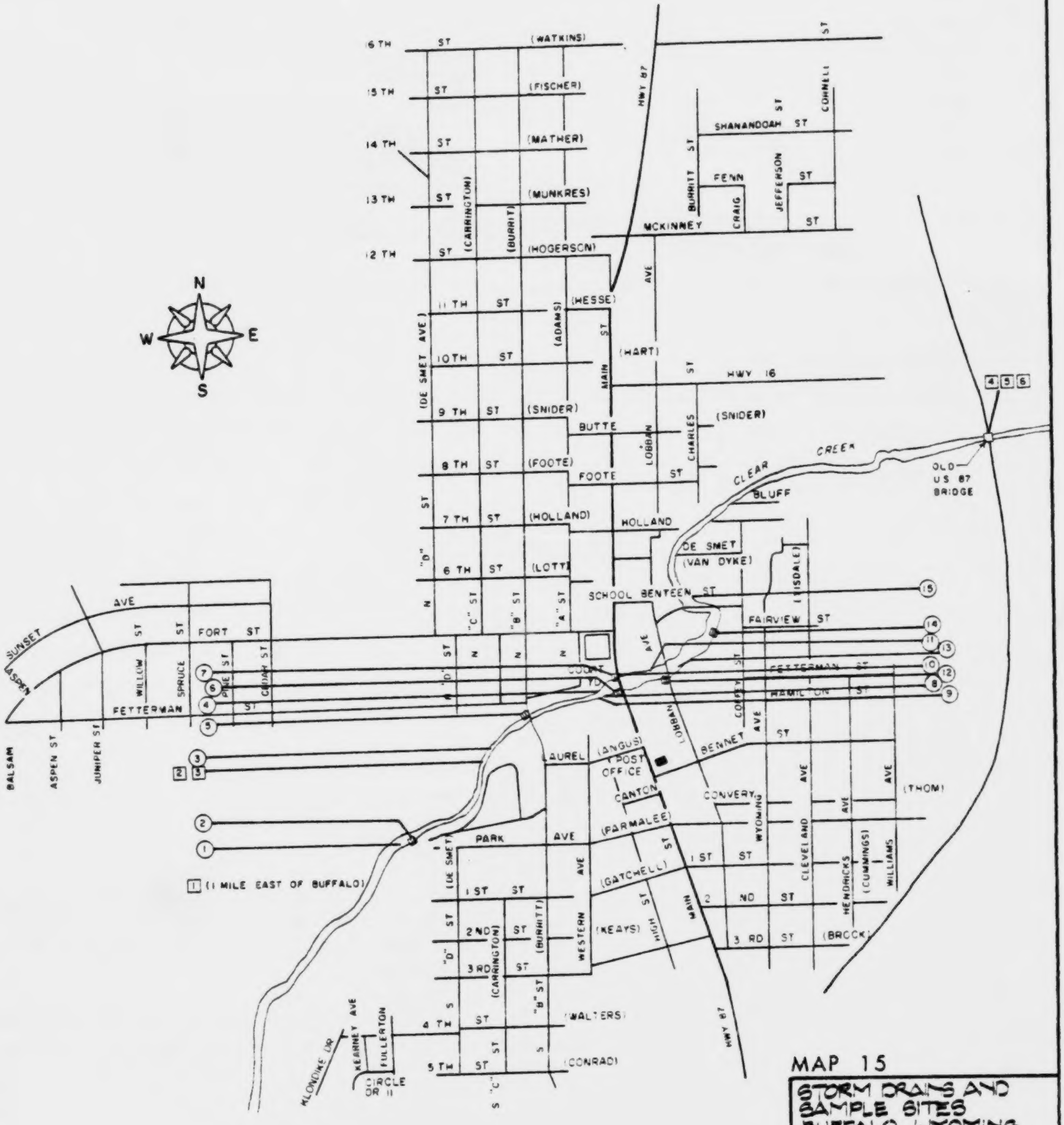
Storm Drainage System

Due to the topography of the City, storm sewer systems have not been a major factor in Buffalo's development. The community essentially contains two operating storm drain systems. One system drains Fort Street east to South Burritt Street, then south on Burritt Street to Clear Creek. The other major system drains Main Street,which was recently completed in the reconstruction of Main Street. Additional street drains provided by reconstruction should assist in the alleviation of the occasional flooding that has occurred in the downtown area. Minor street drains that also flow into Clear Creek are located in the city park and on Lobban Avenue. Storm drain locations are shown on Map 15.

Gillette

Climate

The Gillette area records a semiarid climate characterized by wide variations in annual temperature and seasonal precipitation. The mean annual precipitation amounts to 15.57 inches, with 72 percent of this amount occurring mainly during April and September. The mean yearly temperature is 45.5 degrees. A summary of the mean monthly precipitation for Gillette is presented in Table 53 .


N
S
E
W
16 TH ST (WATKINS)
15 TH ST (FISCHER)
14 TH ST (MATHER)
13 TH ST (MUNKRES)
12 TH ST (HOGERSON)
11 TH ST (HESSE)
10TH ST
9 TH ST (SNIDER)
8 TH ST (FOOTE)
7 TH ST (HOLLAND)
6 TH ST (LOTT)
(CARRINGTON)
(BURRITT)
(ADAMS)
(DE SMET AVE)
N "D" ST
"C" ST
"B" ST
"A" ST
N
HWY 87
MAIN ST
(HART)
AVE
ST
HWY 16
MCKINNEY
BURRITT ST
FENN
CRAIG
JEFFERSON
ST
SHANANDOAH ST
CONNELL
BUTTE
LOBBAN
CHARLES
(SNIDER)
FOOTE
HOLLAND
CLEAR CREEK
BLUFF
DE SMET
(VAN DYKE)
(TISDALE)
SCHOOL
BENTEEN ST
FAIRVIEW ST
FETTERMAN ST
HAMILTON ST
OLD U.S. 87 BRIDGE
4 5 6
SUNSET AVE
ASPEN
WILLOW ST
SPRUCE ST
FORT ST
PINE ST
CEDAR ST
FETTERMAN ST
BALSAM
ASPEN ST
JUNIPER ST
COURT YD
AVE
COFFY ST
CLEVELAND AVE
AVE
AVE
(THOM)
LAUREL
(ANGUS)
POST OFFICE
LOBBAN
BENNET ST
CANTON
CONVERY
WYOMING
(PARMALEE)
PARK AVE
(DE SMET)
1 ST ST
2ND ST
3RD ST
(CARRINGTON)
(BURRITT)
"D" ST
S
"B" ST
WESTERN AVE
(GATCHELL) 1 ST ST
(KEAYS)
HIGH ST
MAIN
2 ND ST
3 RD ST
(BROCK)
HENDRICKS
(CUMMINGS)
WILLIAMS
HWY 87
4 TH ST (WALTERS)
5 TH ST (CONRAD)
S "C" ST
S
KLONDIKE DR
KEARNEY AVE
FULLERTON
CIRCLE DR II
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
2 3
1 (1 MILE EAST OF BUFFALO)

MAP 15

STORM DRAINS AND SAMPLE SITES BUFFALO, WYOMING

▮ - STORM DRAIN

3 - CLEAR CREEK WATER QUALITY SAMPLE SITE

⑥ - CLEAR CREEK RUNOFF SAMPLE SITE

TABLE 53

Mean Monthly Precipitation, Gillette

Month	Precipitation (inches)	Month	Precipitation (inches)
January	.53	July	1.49
February	.59	August	1.02
March	.83	September	1.39
April	1.91	October	.98
May	2.91	November	.76
June	3.33	December	.55

Source: Urban Runoff Study, Sheridan, Buffalo, and Gillette, Wyoming, Water Resources Research Institute, p. 8.

Storm Drainage System

At present, Gillette does not maintain existing storm drain facilities other than underground drains that are located at Gillette Avenue. Various drainage ditches located in the City serve to carry away stormwater.

Water Quality Data

The following narrative presents a review of water quality information and urban runoff chemical data pertaining to Goose Creek at Sheridan, Clear Creek at Buffalo, and Stonepile-Donkey Creek at Gillette. In the State of Wyoming there are three classes of water (DEQ, 1974):

Class I. Those waters which, based on information supplied by the Wyoming Game and Fish Department, are determined to be presently supporting game fish or have the hydrologic and natural water quality potential to support game fish.

Class II. Those waters which, based on information supplied by the Wyoming Game and Fish Department, are determined to be presently supporting nongame fish or have the hydrologic and natural water quality potential to support nongame fish.

Class III. Those waters which, based on information supplied by the Wyoming Game and Fish Department, are determined not to have the hydrologic or natural water quality potential to support fish.

Goose Creek

Goose Creek arises as two forks, Big and Little Goose Creeks, on the eastern slope of the Bighorn Mountains. The confluence of the two forks occurs within the city limits of Sheridan near the intersection of Brooks and First Streets. Goose Creek is presently classified as a Class I stream.

Water Quality -

The water quality of the mainstem of Goose Creek is generally good. Salinity is the major problem, and can mostly be attributed to nonpoint sources, including irrigation return flows. Septic systems apply domestic stresses on the upper reaches of Big Goose and Little Goose. An additional stress is applied on Little Goose Creek as it flows through South Sheridan due to inadequate septic systems. The major stress on the stream occurs at the Sheridan sewage treatment plant. Increases in salinity and nutrients and a marked decrease in dissolved oxygen in the stream occur after this point in the stream.

Water Quality Sample Sites -

The data presented for water quality base information are from samples collected throughout the 208 study area in the Powder River Basin. The sampling sites for Little Goose, Big Goose, and Goose Creeks are illustrated on Map 14 and the base data appear in Table 54 . The data are presented in upstream to downstream order, beginning above Sheridan and continuing through and below the city.

Table 54

Little Goose, Big Goose and Goose Creek Water Quality Data[1]

Site	Cal-cium	Magne-sium	Sodium	Potas-sium	Car-bonate	Bicar-bonate	Sulfate	Chloride	Nitrate	Fluo-ride	TDS	pH (SU)	Ec (μmhos)	Hard-ness	Sodium %	Boron	Silica	TSS	Total O_3	Flow (cfs)
Little Goose																				
1	67	40	23	2.1	0	370	69	3	.2	.4	394	8.2	660	330	13.10	2.1	8.5	13	181	
2	45	29	19	1.9	18	220	73	5.4	.1	.3	318	8.9	506	230	15	.6	7.1	16	126	68
3	28	16	10	1.2	9	130	38	1.8	.2	.3	188	8.9	291	130	14	.4	9.5	52	72	131
4	58	58	45	3.3	15	310	120	3.7	.2	.5	466	8.6	700	330	15	1.2	11	4	167	46
Big Goose Above and Through Sheridan																				
1	48	122	17	1.9	0	170	110	1.9	.1	.3	328	8.3	478	220	14	.6	9.7	16	83	
2	51	30	22	2.1	12	190	130	5.4	.1	.3	390	8.9	580	250	16	.6	7.4	12	105	51
3	54	35	20	3	9	200	140	3.7	0	.4	400	8.5	600	280	13	.8	8.8	16	107	
4	15	6.5	4.1	1.2	0	67	19	1.9	.3	.2	106	8.2	147	65	12	.3	6.8	44	33	
5	54	39	26	4	0	260	140	5.6	1.1	.4	416	8.3	645	290	16	1.1	10	68	128	
6	16	6.1	6.4	.9	3	61	18	1.9	.4	.3	118	8.6	136	66	18	.5	6.7	100	33	
Goose Below Sheridan																				
7	51	33	23	2.3	9	230	110	7.2	.6	.4	382	8.6	598	260	16	.8	7.6	28	122	137
8	15	6.3	4.7	.9	0	67	19	1.9	.4	.2	104	8.1	150	65	14	.3	6.8	44	33	
9	58	42	27	4.2	0	280	140	3.7	1.6	.4	456	8.2	686	320	16	1.0	11	64	138	250

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[1] All concentrations are in mg/l unless noted.

Source: Urban Runoff Study, Sheridan, Buffalo, and Gillette, Wyoming, Water Resources Research Institute, p.11 & 13.

Storm Drain Sample Sites -
A preliminary reconnaissance was conducted by PRAPO personnel on Goose Creek on June 6, 1976, during rain events. Thirty-six (36) storm drain and instream samples were collected during the study and analyzed for conductance and turbidity. Another sample run was conducted during the week of February 2-7, 1977, for snow runoff. Twenty-six (26) samples were collected during this study and were analyzed for various chemical constituents. The sample sites are labeled on Map 14 and data from these sites are contained in Tables 55 and 56.

Clear Creek

Clear Creek also rises on the eastern slope of the Bighorn Mountains. The stream proceeds through Buffalo in a northeasterly direction, confluencing with Piney and Buffalo Creeks prior to emptying into the Powder River approximately ten miles from Montana.

Water Quality -
Buffalo's single-celled lagoon is the only major point source of pollution on Clear Creek leading to and through Buffalo. A minor point source exists immediately west of Buffalo at the Soldiers and Sailors home. Nonpoint sources such as septic tank seepage affect the upper reaches of the stream. Clear Creek is classified as a Class I stream, and therefore must conform to the standards developed for this type of stream.

Water Quality Sample Sites -
Limited base data (three samples above Buffalo and three samples below) were obtained by the Water Resources Research Institute. Sample sites are represented on Map 15 and the chemical data are presented in Table 57.

Storm Drain Sample Sites -
A total of 15 urban runoff samples during snowmelt runoff were collected along Clear Creek on February 8, 1977, by PRAPO personnel. The sample sites are also labeled on Map 15 and the chemical data are presented in Table 58.

Table 55

Little Goose Creek storm runoff data (collected Feb. 2, 1977)[1]

Site	Calcium	Magnesium	Sodium	Potassium	Carbonate	Bicarbonate	Sulfate	Chloride	Nitrate	Fluoride	TDS	pH (SU)	Ec (μmhos)	Hardness	Sodium %	Boron	Silica	TSS	Total CO3	Phosphate Ortho/total	Flow (cfs)
1	51	37	21	1.9	0	300	66	2.8	2.6	.4	400	8.2	636	280	14	.08	12	12	150	.03/.06	~41
2	86	34	35	1.9	0	200	210	33	1.6	.3	586	7.7	836	360	17	.07	11	52	96	.1/.13	
3	66	37	21	1.9	0	340	70	2.7	2.4	.4	402	8.2	655	320	14	.07	12	8.0	170	.04/.05	
4	89	19	36	4.9	0	220	120	55	3.8	.4	496	7.3	761	300	20	.05	8.4	412	110	.42/.50	
5	65	36	21	2.1	0	340	69	3.4	2.6	.4	422	8.2	655	310	13	.07	12	8.0	170	.05/.07	
6	19	5.0	4.7	1.4	0	60	9.0	12	1.6	.2	108	7.4	188	67	13	.05	11	0	29	.11/.13	
7	67	9.2	13	5.6	0	120	110	23	8.9	.4	368	7.4	523	200	12	.08	4.7	548	53	.56/.58	
8	82	5.3	17	6.3	0	160	75	38	5.4	.1	366	7.2	549	230	14	.09	6.0	380	78	.32/.39	
9	94	6.1	100	6.1	0	130	110	180	6.4	.1	612	7.1	1020	260	45	.13	4.4	288	63	.26/.33	
10	84	5.8	19	6.3	0	160	99	38	.2	.2	386	7.4	595	230	14	.10	7.2	552	78	.37/.40	
11	92	6.1	25	4.4	0	130	120	42	14	.3	414	7.7	637	260	17	.07	6.4	1080	66	.60/.61	
12	120	9.2	36	8.4	0	120	180	73	28	.2	588	7.7	842	330	19	.09	6.4	360	60	.37/.41	
13	68	39	23	2.1	0	330	94	4.1	3.5	.5	438	8.2	690	330	13	.1	11	24	160	.03/.04	

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[1] All concentrations are in mg/l unless noted.

Source: Urban Runoff Study, Sheridan, Buffalo, and Gillette, Wyoming, Water Resources Research Institute, p. 15.

Table 56

Big Goose and Goose Creek storm runoff data (collected Feb. 7, 1977)[1]

Site	Calcium	Magnesium	Sodium	Potassium	Carbonate	Bicarbonate	Sulfate	Chloride	Nitrate	Fluoride	TDS	pH (SU)	Ec (umhos)	Hardness	Sodium %	Boron	Silica	TSS	Total CO_3	Phosphate Ortho/total	Flow (cfs)
1	81	40	26	2.3	0	270	180	2.4	2.1	.5	506	8.3	754	370	13	.1	12	4	130	.01/.02	.31
2	95	31	28	4.7	0	220	210	29	12	.4	608	7.6	855	360		.11	10	452	110	.29/.30	
3	81	46	27	3.0	0	250	200	14	7.7	.6	574	8.1	303	390	13	.1	11	64	120	.08/.13	
4	91	6.9	35	7.9	0	99	150	64	8.4	0	476	7.2	723	260	23	.09	6.9	176	49	.37/.42	
5	110	25	35	7.2	0	180	220	51	7.8	.4	624	7.5	878	380	16	.09	7.1	248	87	.31/.39	
6	76	39	26	2.8	0	270	180	2.7	2.2	.5	512	8.2	756	350	14	.09	12	8	130	.02/.03	
7	120	8.8	39	7.0	0	150	210	66	.2	.4	580	7.7	874	340	20	.09	8.9	2050	75	.86/.87	
8	72	7.3	23	5.4	0	150	85	44	0	.3	378	7.7	586	210	19	.04	6.6	500	76	.68/.74	
9	47	5.7	21	5.4	0	98	67	33	1.9	.3	282	7.0	431	140	24	0	5.6	120	48	.28/.35	
10	57	5.1	15	5.4	0		68	35	2.3	.3	304	7.3	453	160	16	0	6.3	210	51	.31/.41	
11	32	33	25	.7	0	230	81	3.6	.9	.5	352	8.3	527	210	20	.03	13	96	110	.05/.11	
12	80	8.7	20	4.9	0	160	110	34	2.5	.4	416	7.7	612	240	15	.02	5.2	570	78	.45/.46	
13	61	7.2	35	4.4	0	150	57	58	.6	.3	350	7.8	552	180	29	.01	64	490	72	.49/.53	

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[1] All concentrations in mg/l unless noted.

Source: Urban Runoff Study, Sheridan, Buffalo, and Gillette, Wyoming, Water Resources Research Institute, p. 17.

Table 57

Clear Creek water quality data[1]

Site	Calcium	Magnesium	Sodium	Potassium	Carbonate	Bicarbonate	Sulfate	Chloride	Nitrate	Fluoride	TDS	pH (SU)	Ec (µmhos)	Hardness	Sodium %	Boron	Silica	TSS	Total CO_3	Phosphate Ortho/total
Above Buffalo																				
1	12	3.3	7	1.2	0	58	12	1.4	0	.2	72	7.8	115	44	26	.3	9.8	8	28	
2	9.3	1.7	3.5	.7	0	31	9.9	1.9	0	.1	54	7.7	64	30	20	0	7.8	12	15	
3	17	4.3	9.4	.9	0	70	19	1.5	0	.2	92	8.0	148	59	25	0	11	8	34	.02
Below Buffalo																				
4	6.1	1.1	1.8	.2	0	31	0	1.9	.4	.1	58	8.3	52	20	17	.1	6	8	15	
5	9.3	1.8	3.5	.7	0	27	15	1.9	0	.1	58	7.1	66	31	20	0	7.7	12	13	
6	15	3.9	8.8	1.2	0	67	19	1.2	0	.2	86	7.9	139	55	26	0	10	4	33	

[1] All concentrations in mg/l unless noted.

Source: Urban Runoff Study, Sheridan, Buffalo, and Gillette, Wyoming, Water Resources Research Institute, p. 19.

Table 58

Clear Creek storm runoff data (collected Feb. 8, 1977)[1]

Site	Calcium	Magnesium	Sodium	Potassium	Carbonate	Bicarbonate	Sulfate	Chloride	Nitrate	Fluoride	TDS	pH (SU)	Ec (umhos)	Hardness	Sodium %	Boron	Silica	TSS	Total CO_3	Phosphate Ortho/Total
1	36	9.8	16	.9	0	130	57	1.8	.2	.3	226	8.3	348	130	21	0	12	16	66	.01/.02
2	39	9.2	110	1.6	0	110	52	170	.4	.2	496	7.3	874	130	64	0	1.4	64	55	.06/.11
3	32	9.1	19	1.2	0	130	51	.9	.8	.2	216	7.6	336	120	26	0	12	12	63	.01/.01
4	32	9.0	20	1.2	0	130	53	1.8	.9	.2	222	8.0	351	120	27	.01	12	12	66	.03/.03
5	57	8.6	72	4.2	0	190	52	97	.1	.2	436	7.6	733	170	46	0	5.7	780	94	.41/.57
6	52	9.9	220	6.1	0	190	14	350	0	.3	840	7.7	1520	170	73	.03	9.6	4400	93	.11/.11
7	50	7.4	130	5.6	0	180	13	200	0	.2	556	7.7	1020	160	64	.01	6.3	1500	86	.58/.92
8	50	6.7	120	3.5	0	160	9.0	210	.4	.2	512	7.9	953	150	63	.23	4.5	2000	77	.56/.58
9	43	6.5	150	3.3	0	140	8	230	.8	.1	520	7.7	904	130	70	.03	4.7	1220	71	.53/.43
10	110	12	190	5.1	0	360	0	310	0	.3	994	7.2	1620	330	56	.09	17	3000	180	.06/.18
11	37	9.6	20	1.6	0	140	54	7.3	.2	.2	236	8.0	371	130	24	.06	12	48	68	.03/.07
12	59	11	200	3.7	0	180	16	350	.1	.3	818	7.6	1470	190	69	.06	5.8	780	87	.36/.49
13	65	14	310	8.4	0	210	16	530	0	.3	1160	7.7	1970	220	75	.19	9.3	6800	110	.15/.17
14	56	9.7	280	3.5	0	190	25	440	.3	.4	986	7.8	1810	180	77	0	6.3	5900	93	.29/.27
15	38	9.7	22	1.4	0	190	53	12	.2	.2	238	8.0	385	140	26	0	11	120	70	.09/.14

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[1] All concentrations in mg/l unless noted.

Source: Urban Runoff Study, Sheridan, Buffalo, and Gillette, Wyoming, Water Resources Research Institute, p. 21.

Stonepile-Donkey Creek

Stonepile- Donkey Creek is a Class III stream until it flows to the Campbell-Crook County line, where it becomes a Class II stream. During drought flow conditions, the only flow observed in the drainage is treated sewage from Gillette's wastewater treatment plant. An elaborate presentation on the impact of urban runoff on Stonepile-Donkey Creek was not undertaken since it is a Class III stream. However, street samples were collected in Gillette at the sites shown on Map 16 and samples results are presented in Table 59.

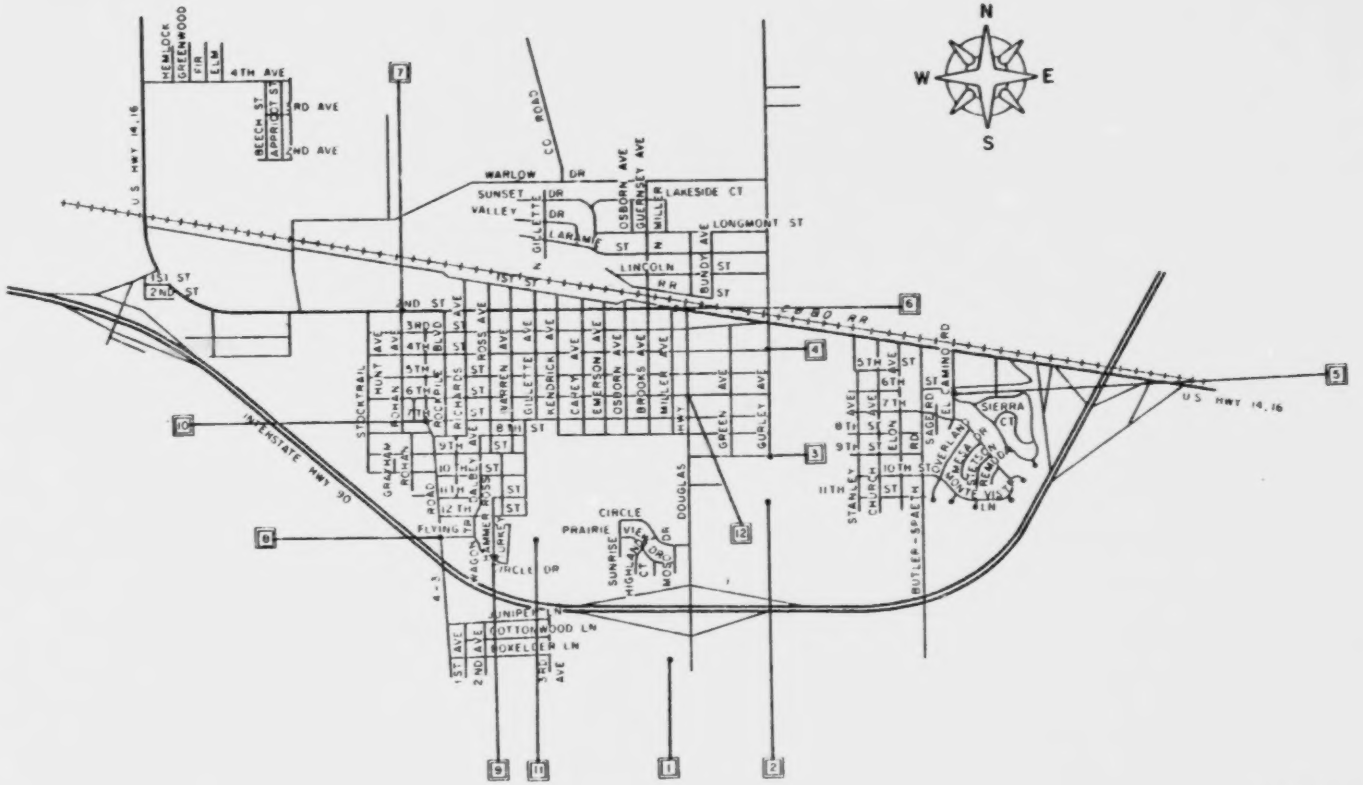
Water Quality Runoff Assessment

The data analyzed by the Water Resources Research Institute were not sufficient to determine overall and long-range impacts of stormwater on Goose Creek and Clear Creek. If a complete and accurate study is desired, more comprehensive sampling techniques should be employed. This would include the use of automatic samplers to sample runoff events during rising and rescinding limbs of the hydrograph. Modeling could also be utilized to estimate downstream effects of urban runoff.

Generally speaking, minimal impact is observed on both Goose Creek and Clear Creek from the runoff events sampled for this study. The following is a description of the impact of stormwater on these streams.

Goose Creek

As expected, storm drains along this waterway contain high concentrations of suspended solids and total dissolved solids. Suspended solids are consistently higher than stream levels in drains sampled on both forks of Goose Creek. However, extremely high downstream concentrations were not observed. Two processes operating together are probably responsible for this result. One is dilution, which decreases total dissolved solids concentrations. The other is sedimentation, which causes an immediate dropout of the heavier street particles observed in urban runoff. The reconnaissance conducted on June 6, 1976, supports this observation. During this study conductance and turbidity were observed to decrease in value from immediately below the confluence of Big Goose and Little Goose Creeks to the Fort Road Bridge. A comparison of sampling sites 1 and 5 on Little Goose Creek (Table 55) also indicates a decrease of suspended solids from 12 mg/l to 8 mg/l. A three-fold increase is observed at site 13 as compared to site 5; however, the drains between these two sites contain suspended solids concentrations up to 135 times higher than stream levels. A comparison of Table 55 with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3RD AVE
2ND AVE
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APPRICOT ST
CO ROAD
WARLOW DR
SUNSET DR
VALLEY DR
GILLETTE
LARAMIE ST
OSBORN AVE
GUERNSEY AVE
MILLER
LAKESIDE CT
LONGMONT ST
LINCOLN
RR
BUNDY AVE
1ST ST
2ND ST
3RD
4TH
5TH
6TH
7TH
8TH ST
9TH
10TH
11TH
12TH
BLVD
STOCKTRAIL
HUNT AVE
ROHAN
RICHARDS
ROSS AVE
WARREN AVE
GILLETTE AVE
KENDRICK AVE
CAREY AVE
EMERSON AVE
OSBORN AVE
BROOKS AVE
MILLER AVE
HWY
GREEN AVE
GURLEY AVE
DOUGLAS
GRAHAM
ROAD
FLYING
WAGON
LAMMER ROSS
CIRCLE DR
4-J
JUNIPER LN
COTTONWOOD LN
BOXELDER LN
1ST AVE
2ND AVE
3RD AVE
CIRCLE
PRAIRIE
VIEW
SUNRISE
HIGHLAND
CT
MOSO DR
5TH AVE
6TH
7TH
8TH AVE
9TH ST
10TH ST
11TH
STANLEY
CHURCH
ELON
RD
BUTLER-SPAETH
SAGE RD
EL CAMINO RD
OVERLAND
MESA
SIERRA CT
MONTE VISTA LN

MAP 16

SAMPLE SITES

GILLETTE, WYOMING

7 - RUNOFF SAMPLE SITE LOCATION

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Table 59

Gillette storm runoff data (collected February 5, 1977)[1]

Site	Calcium	Magnesium	Sodium	Potassium	Carbonate	Bicarbonate	Sulfate	Chloride	Nitrate	Fluoride	TDS	pH (SU)	Ec (umhos)	Hardness	Sodium %	Boron	Silica	TSS	Total CO3	Phosphate Ortho/total
1	52	5.1	89	8.4	0	180	25	130	.1	.3	454	7.1	750	150	55	.17	8.4	616	88	.69/1.17
2	91	3.6	40	6.1	0	180	13	120	.1	.2	466	7.3	697	240	26	.06	7.1	844	86	.27/.59
3	70	13	130	16	0	280	140	100	1.8	1.2	678	7.5	1010	230	54	.19	16	5760	140	.11/.70
4	70	7.3	270	9.5	0	200	59	400	.1	.5	936	7.3	1590	210	73	.09	13	5170	100	.05/.12
5	130	20	70	8.8	0	150	350	72	.1	.6	842	7.2	1080	400	27	.11	6.8	952	75	.45/.65
6	73	7.4	210	11	0	300	0	320	0	.4	814	7.3	1370	210	67	.31	13	1810	150	.02/.06
7	74	5.8	100	8.4	0	170	73	84	1.3	.4	550	7.5	923	210	51	.01	9.1	1500	84	.51/.60
8	62	5.6	77	9.3	0	140	69	120	4.3	.3	460	7.2	730	180	47	.03	6.4	200	70	.62/.69
10	81	12	39	5.8	0	120	160	47	2.9	.4	462	7.4	683	250	24	.01	6.2	604	60	.34/.42
11	85	3.7	430	8.8	0	190	33	720	.1	.3	1360	7.3	2380	230	80	.04	8.0	1100	95	.44/.64
12	62	4.7	280	8.4	0	200	47	420	.1	.4	922	7.5	1690	170	77	.06	9.1	3000	99	.03/.16

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[1] All concentrations in mg/l unless noted.

Source: Urban Runoff Study, Sheridan, Buffalo, and Gillette, Wyoming, Water Resources Research Institute, p. 23.

Table 54 for Little Goose Creek and Table 56 with Table 54 for Big Goose and Goose Creek indicates that suspended solid concentrations are somewhat comparable between wet weather flows and dry weather flows. However, consideration must be given to instantaneous discharges in arriving at these conclusions. The high concentrations of suspended solids in storm runoff is most probably due to fine solids and silts being washed off the streets.

The major components of total dissolved solids that were observed in Little and Big Goose Creeks appeared to be higher in concentrations than in storm runoff from Goose Creek. These components included calcium, sodium, potassium, sulfate, chloride, and, to a limited extent, nitrate. Sodium, calcium, and chloride concentrations are probably a result of highway de-icing salts being washed off the streets. These salts, when ionized in water, are not usually a serious water quality threat. Sodium also does not combine readily with other elements in water, and therefore will not precipitate out of solution; thus, sodium concentrations tend to remain high in water systems. The chemical behavior of chlorides in water is quite neutral, as they commonly form solute complexes with other ions, do not form salts of low solubility, are not significantly absorbed on mineral surfaces, and maintain insignificant biochemical roles. Calcium is the principle cation in most natural fresh waters, due to the fact that it is abundantly distributed in common minerals of the soil.

Sources of potassium in runoff are more difficult to trace than other elements. Potassium is a major component of sedimentary rocks, but it is also an important plant nutrient. The nutrient is removed from the soil by the plant, but is returned to the soil when the plant dies. The effect of plants and addition of fertilizers to the soil may be important factors in the circulation of potassium in the runoff of Sheridan.

Nitrates are most commonly attributed to mammalian wastes that enter the water, but it is also an important plant nutrient; therefore, soil leaching is another important source of nitrates. Most probably, the nitrates observed in runoff in Sheridan are a combination of animal feces entering the water and soil leaching of lawns in the area.

Sulfate concentrations may be attributed partly to the combustion of fuels that are discharged through exhaust pipes of automobiles. However, another significant source is precipitation itself. Concentrations of 1 mg/l of sulfate in rainwater is common with concentrations of 10 mg/l being reported.

Minor elevations in phosphates were also observed in the snowmelt runoff at Sheridan, with the majority being in the form of ortho-phosphates. Ortho-phosphates are used as "builders" in many fertilizers applied to lawns.

Clear Creek

Snowmelt runoff from Buffalo into Clear Creek also contains high concentrations of suspended solids. Table 58 indicates that suspended solids increase by 104 mg/l after the Creek passes through the storm drain area of Buffalo. The major contributors of suspended solids seem to be sites 6, 7, 8, 10, 13, and 14. These sites drain two major streets in Buffalo including Main Street (sites 6 and 7) and Lobban Avenue (site 14). Additional pollution seems to originate in parking lots and alleys located in the central business district of Buffalo (sites 8, 10, and 13). Fine solids on street surfaces are possible causes of high suspended solids concentrations from storm drain runoff.

The increase in total dissolved solids can be almost entirely attributed to road salts. This is most dramatically demonstrated at the Main Street drains (sites 6 and 7) and the Lobban Avenue drain at site 12. A marked increase in sodium, chloride, and calcium is observed at these sites. Other constituents (magnesium, sulfate, nitrate, and fluoride) actually decrease from site 1 to site 15, indicating dilution is overcoming the loading effect for these constituents.

Stonepile-Donkey Creek

Gillette's storm runoff data were previously presented in Table 59 . The same problems and patterns are observed in the data as observed in Sheridan and Buffalo. Urban runoff is not a significant pollutant source based on the results of observed water quality data and the ephemeral character of Stonepile-Donkey Creek.

Suggested Management Guidelines

Table 60 suggests best management practices (BMPs) for the types of pollutants observed in the Sheridan, Buffalo, and Gillette areas. The practices presented in Table 60 are basically excerpts from the Environmental Protection Agency's "Urban Runoff Pollution Control Technology Overview". The Water Resources Research Institute suggests that these are possible practices, but not absolute solutions for treatment of total and suspended solids in urban runoff. It should be recognized that the Environmental Protection Agency has conducted their studies for larger metropolitan areas than are located in Wyoming. The larger cities maintain a broader financial base for construction or urban pollution control structures. It is doubtful that the benefits obtained from expensive pollution control techniques in Wyoming would be greater than the cost of applying the techniques.

Programmatic Activities

The Federal Water Pollution Control Act Amendments of 1972 (Public Law, 92-500) made discharges of pollutants into navigable waters illegal without a permit. However, most storm sewers and agricultural irrigation return flows were excluded from the requirement of having a National Pollutant Discharge Elimination System (NPDES) permit. This exclusion was challenged in court; as a result, the Environmental Protection Agency was ordered to propose and promulgate regulations extending the permit program to previously excluded categories.

The proposed general permit program will include storm drains. The "General Permit Program Area" (GPPA) would consist of a designated geographical area in which all owners or operators of separate storm sewers, exclusing those covered by individual permits, are subject to the same general permit. Depending on the situation, a permit area could be as large as an entire state or as small as a local political or organizational division.

Under the proposed regulations, the States that have been delegated the NPDES permit program would be given an opportunity to develop a general permit program. The State would have a choice of using a general permit and/or individual permits for permitting "separate storm sewers". To be considered a "separate storm sewer", the storm sewer must be within an urbanized area (not SMSA) or designated as a significant source of pollution.

TABLE 60

Suggested Management Guidelines for Urban Storm Runoff

BMP	Distributive Effects	Water Quality Effects
LAND MANAGEMENT (STRUCTURAL/SEMI-STRUCTURAL)		
On-site storage	Multi benefits of aesthetics, recreation, recharge, and irrigating reduces erosion.	Reduction in TDS, sediments. Potential groundwater pollution should b considered. Reduces instream scouring.
Overland flow modification	Lower cost than subterranean sewer construction, allow vegetative cover and soil infiltration.	
LAND MANAGEMENT (NON-STRUCTURAL)		
Improved surface sanitation	Aesthetics.	Reduction in finer solids concentration, reduction in TDS and organic loadings.
Chemical use control	Public health could increase if the public was educated in economical and nonwasteful methods of applying fertilizers and pesticides. Economic benefit could be gained from using less salt for de-icing highways.	Reduction in complex inorganic loadings which do not degrade through natural stream cleansing, reduction in nutrients.
Urban development resource planning	Better urban planning and reduction in erosion and sedimentation.	Reduction in TDS and sediments.
Use of natural drainage	Reduces drainage costs, enhances aesthetics. Groundwater supplies and flood protection.	Reduction in TDS, sediments, and nutrients.
Erosion and sediment control	Enhance aesthetics through seeding and sodding.	Reduces instream scouring by reducing flows.
STORAGE		
Storage - concept is to capture wet-weather flow and blend it back into the treatment plant during dry weather. Essentially storage chops the top off a storm hydrograph.	Probably most cost-effective method for reducing pollution from treatment plant overflows.	Reduction in sediments and eliminates shock loadings.

Source: Draft, Urban Runoff Study: Sheridan, Buffalo and Gillette, Wyoming, Water Resources Institute, University [illegible]

With uncertainty pertaining to regulations concerning storm drains, it would be worthwhile for the appropriate agencies to be aware of certain urban pollution control techniques for future urban development policies. The most feasible techniques for smaller cities would be constructural land management techniques. These include improved surface sanitation, chemical use control, and better urban planning in new housing districts.

The data evaluated pertaining to urban runoff are not sufficiently thorough for an accurate evaluation of the effects of urban runoff in the Sheridan, Buffalo, and Gillette areas. The data lack many key parameters such as BOD, metals, oil and grease, and bacterial determinations for the samples collected. Additionally, it is also pertinent to measure the quantity of water being discharged into the receiving streams which requires an instantaneous discharge measurement at each storm drain. Composite samples during the runoff event should also be obtained. This procedure would require sampling of each storm sewer at the beginning, midpoint, and at the end of the runoff event. Use of automated samplers would provide much better results than manual collection of the samples. Lastly, it is important to determine the loading factors by sampling runoff from a number of rain and snowstorms throughout the year.

The following conclusions and program features were based on the data presented in the Urban Runoff Study:

1. The major pollutant problems observed in the Sheridan, Buffalo, and Gillette areas are dissolved and suspended solids. The major portion of dissolved solids occur from road de-icing salts, while the suspended solids are attributable mostly to the fine solids and silts present on the street surface.

2. Metals are associated with suspended solids as they adhere to mineral surfaces; therefore, it is suggested that metal analyses be conducted on those drains which have high suspended solids concentrations.

3. The most practical approach to reducing the urban pollution potential in these areas is improved street sweeping procedures. The Environmental Protection Agency has observed that a broom and vacuum combination street

cleaner can reduce dry weight solids by 93 percent, volatile solids by 80 percent, BOD by 67 percent, COD by 84 percent, total PO_4-P by 85 percent, and heavy metals by 83-98 percent at the street surface.

4. Urban runoff from these areas exhibits a short term effect on the receiving streams. However, downstream effects, such as nutrient buildups in the Tongue River Reservoir, should be investigated.

HIGHWAY AND ROAD CONSTRUCTION ASSESSMENT[1]

Introduction

Highway and road construction projects consist of high risk activities with regard to their potential for contributing sediments and other pollutants to surface and ground waters in Wyoming. This primarily results from the high susceptibility of disturbed soils, drainages, or stream channels to erosion due to a number of factors. Consequently, uncontrolled road construction activities can generate large amounts of sediments from relatively small areas.

1. Although Wyoming climate is basically arid, effective precipitation tends to occur in the form of intense thunderstorms and snowmelt, both of which result in rapid surface runoff.
2. Soils in many areas of the state are noncohesive, with poor structural stability, low organic content, shallow depth of topsoil. Consequently, they are highly susceptible to both wind or water erosion.
3. Once disturbance occurs, re-establishment of vegetative cover is difficult to achieve because of the arid climate and poor soil and conditions.
4. In many areas of the State, high winds blow continually and over long distances during much of the year, greatly increasing the potential for wind erosion.
5. In some areas, natural erosion significantly impacts water quality; in these areas any disturbances may significantly increase the problem.
6. In many areas, soil texture is such that soils are susceptible to packing by heavy machinery; this may cause pan formation with irreversible puddling and runoff, thereby increasing erosion potential in adjacent areas.

Wyoming's water resources are limited and warrants that measures be included in road construction projects and maintenance activities to ensure that water quality goals and standards are met. Technology currently is available to control, within reasonable limits, the erosion and sedimentation that may originate at road construction sites, both during and following construction.

To a large extent, good highway and road design practices protect water quality by incorporating erosion control efforts that protect highway structures and reduce maintenance costs. In this respect, highway departments have design standards and construction specifications which incorporate many protective measures that eliminate or reduce runoff and erosion. In most cases, erosion control measures currently prepared for most highway projects are adequate to limit erosion and sedimentation problems to reasonable levels. However, erosion control and water quality protection measures are effective only if they are implemented and enforced. Their need and importance must be recognized by planning, design, administrative, and construction personnel, i.e., they must be installed properly, in the right places at appropriate times and then adequately maintained. In general, the implementation of effective erosion controls during a construction project not only protects water quality, but also reduces post construction control requirements and costs.

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[1] Based on information developed by the Wyoming Highway Department and the Wyoming Department of Environmental Quality

The Wyoming State Highway Department conducts by far the largest road construction program in the State. Included in the program are improvements to state highways in rural and urban areas, county roads and city streets. Other road building entities include Federal agencies, counties, cities and private industry; however, the construction programs of these entities are rather minor and virtually insignificant when compared to the State Highway Department's program.

Best Management Practices Process

The Highway Department, in conjunction with the Department of Environmental Quality, has developed a State Highway Construction Best Management Practices Process which outlines a procedure to accomplish construction pollution abatement at the State level. This procedure will be implemented through the Wyoming Highway Department Action Plan, which outlines the organizational arrangement, responsibilities, and procedures to be followed in developing highway projects. These procedures and guidelines will be applicable to federal, county, local and private projects, and will be integrated into local Wyoming Water Quality Management Plans. Adherence to this procedure will assure that the planning, design, construction and maintenance of highways and streets will meet water quality goals and standards.

Specifically, this process includes:

1. Procedures and Methods of Developing Control Plans.
2. Administrative Procedures and Responsibilities for Developing, Reviewing, Approving and Implementing Management Practies.
3. Guidelines and Criteria for Developing Site Specific Best Management Procedures.

Under 3. above, the Guidelines and Criteria provide consideration for:

Planning and Design.
Erosion Controls and Protection of Water Quality.
Protection of Aquatic Life.
Recreation and Aesthetics.
Post-Construction Activities.
Legal Restrictions.

ON-SITE WASTE DISPOSAL ASSESSMENT[1]

Introduction

The use of on-site disposal systems in the three county area is basically limited to the standard septic tank and leach field system. Some use is also made of aerobic tanks for solids removal in conjunction with the standard leach field.

Utilization of on-site disposal systems provides for a number of potential pollution problems which must be recognized and evaluated. These problems are groundwater pollution, leach field failure, non-point stream pollution and septage disposal.

In the three county area, improperly functioning or non-existent septic systems affect three major stream segments:

Little Goose Creek
Big Goose Creek
Powder River near Arvada

Other segments undoubtedly have occurrences of contamination caused by leaching from septic systems also.

In portions of the three counties, high densities of septic systems and potable water wells occur in areas with high groundwater levels, increasing the hazards to public health.

Enforcement of regulations governing the construction of septic systems and water wells has been minimal under State programs. The Counties of Campbell and Sheridan are developing or have developed local programs for permitting and inspecting septic systems and water wells based on State regulations. This is the initial step in developing a more comprehensive and efficient program.

Major recommendations concerning the construction of on-site disposal systems and water wells and the regulations controlling construction are presented below.

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[1] Based on information developed by the staff of the Powder River Areawide Planning Organization.

Programmatic Recommendations

1. Development, adoption and enforcement of water well construction regulations which would take into account all aspects of a program needed to assure proper site selection and proper construction of domestic water wells.
2. Development, adoption and enforcement of on-site disposal regulations which would take into account all aspects of a program needed to assure proper site and system selection, proper construction and continuing maintenance of on-site disposal systems.
3. Establishment of a system of charges for filing of permits and conducting inspections. Fees collected will be used to help defray the costs of running such programs.
4. Employment of the necessary personnel needed to carry out such programs, including a sanitarian with a soils background or, if the work load warrants, a county soils scientist.
5. A process in which existing on-site disposal systems which have failed and are found to be incapable of meeting existing standards be brought into compliance.
6. Requirement making it mandatory that homeowners have their small wastewater system inspected once every three years for standard septic tanks and once every year for mechanical systems by a qualified county official.
7. Requirement that the use of soil absorption fields be limited in sensitive land areas. These areas include floodplains, wetlands, lands with a slope of more than 20 percent, lands with high groundwater, lands with severe soil limitations as shown on the SCS-Soils-5 form and aquifer recharge areas.
8. Requirement that new homes utilizing on-site disposal systems should designate two leach field sites on the approved lot plan. One site to be constructed in conjunction with the new home and an alternate site equal in area to be the primary site for future use.

9. Requirement for detailed field investigations to be conducted by the developer in conjunction with the local regulatory official for all new sewage disposal systems. The field observations should include the following steps:
    a) an observation of groundwater depth during wet months of the year or the criteria in the Soil Taxonomy - "mottles of value 2 or less above 30 inches" that will show saturation levels during the wet season even if the soil is extremely dry;
    b) a standard percolation test run on saturated soils;
    c) a detailed soil report of the soils which extend three feet below the bottom of the leach field trenches;
    d) an evaluation of the need for more detailed site investigation in the presence of restrictive geologic conditions.
10. Requirement that leaching area for elevated leach fields, determined in accordance with the percolation rate, should be based on the bottom area of the drain field trenches.
11. Provisions for the continued role of the local soil conservation districts in interpreting soils information for determining system design requirements.
12. Preparation by the U.S. Soil Conservation Service of complete soils mapping for the entire planning area.
13. Co-sponsorship by local and State level agencies of legislation which would provide State level financial assistance to the counties for instituting management programs regulating water well construction and on-site disposal system construction.
14. County participation in conjunction with the respective city governments of Gillette, Buffalo and Sheridan in the development and implementation of methods for the proper disposal of septic tank solids.

Chapter IV

POINT SOURCE ASSESSMENT AND NEEDS

INTRODUCTION

Public Law 92-500 provides that the analysis of waste treatment alternatives shall include an evaluation of the following:

1. Regional Solutions
2. Alternative Waste Treatment Methods
3. No Action

Regional solutions for the wastewater treatment needs of communities in the three counties are not feasible because of geographic location and distance between communities. It is physically possible to provide a centralized treatment facility to serve the communities of Dayton and Ranchester in Sheridan County, but does not appear economically feasible.

Alternative waste treatment methods must, under the provisions of P.L. 92-500, be further evaluated for the following technologies:

1. Biological or physical-chemical treatment and discharge to receiving waters.
2. Treatment and reuse.
3. Land Application Techniques.

Each of the facilities plans for the incorporated areas analyzed these treatment methods with some degree of thoroughness. The facilities plans at the time of printing of this report were not yet approved by EPA and DEQ. Changes to these documents might occur prior to final approval. This chapter reviews existing wastewater treatment systems, treatment alternatives investigated for each community, their comparative assessments, and the selected alternative. This chapter also contains a summary of the wastewater collection system trunk line studies for the Cities of Buffalo and Sheridan.

WASTEWATER TREATMENT SYSTEMS AND ASSESSMENT

Buffalo

Existing Wastewater Facilities

Existing Collection System -
The City of Buffalo's wastewater flows by gravity into a 1-cell oxidation lagoon located immediately east of Interstate Highway 25. The collection system is constructed in two major drainage areas. The smaller drainage area, the south collection area, serves the higher area of town in the southeastern corner of the City. This area outfalls through a 10" gravity main and presently serves approximately 910 people.

The northern collection area services the remainder of the Buffalo population. This area outfalls through a 15" vitrified clay pipe (V.C.P.) line which joins with the 10" outfall just prior to entering the lagoon. Portions of the wastewater collected in the northern area cross Clear Creek seven times before being delivered to the lagoon.

There are approimxately 17.3 miles of line in the collection system. The system is adequately equipped with manholes at most line termini and at changes in line and grade. The total system is comprised of over 60 percent 6" diameter pipe, 27 percent 8" diameter pipe and the remaining 13 percent of 10" to 15" diameters.

Existing Treatment System -

Sewage is carried to the one-cell lagoon by two interceptor sewers which join in a common manhole immediately west of the lagoon site. The pond itself is described as a facultative[1] pond, which is formed into a hillside with earth dikes around the east, west, and north sides. The earth embankments are constructed with 3:1 interior slopes and 2:1 outside slopes. The treated water discharges into a ditch which directs the discharge around the south end of the lagoon to the point of discharge into Clear Creek. Other physical characteristics of the lagoon are:

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[1] Facultative - Facultative organisms are those which have the ability to survive with or without free oxygen.

Depth	varies	3.0 - 13.5 feet
Capacity		42,800,000 gallons
Surface Area		20.0 Acres
Detention		40 days minimum at a flow of 1 MGD and average depth
Evaporation rate		44 inches/year

Projected Wastewater Loads

As shown in the Wastewater Facility Plan, the projected population for the City of Buffalo amounts to 17,513 persons by 1995 resulting in the following projected wastewater flows (with and without infiltration/inflow (I/I) rehabilitation). Table 61 shows the projected wastewater flows for Buffalo.

TABLE 61

Projected Wastewater Flows

Alternate Flow Conditions	Quantity
Annual Average Daily Flow (AADF)	
1. With I/I Rehabilitation	2.22 MGD
2. Without I/I Rehabilitation	2.85 MGD
Annual Peak Daily Flow (APDF)	
1. With I/I Rehabilitation	2.75 MGD
2. Without I/I Rehabilitation	3.54 MGD
Instantaneous Peak Flows (IPF)	
1. With I/I Rehabilitation	4.27 MGD
2. Without I/I Rehabilitation	5.67 MGD
Design BOD 5-20	300 mg/l
Design Suspended Solids	300 mg/l
Effluent BOD_s	30 mg/l
Effluent Suspended Solids	30 mg/l

Source: (Projected Wastewater Flows) Buffalo, Wyoming Wastewater Facility Plan, Step 1, Exhibit 1, VTN Engineers, Planners, Surveyors, p. XII-3.

Alternatives

Public Law 92-500 specifies a study of reuse potentials for wastewater as well as treatment and disposal alternatives. In order to fully explore these wastewater management alternatives for Buffalo, the following six wastewater management systems were conceptualized, preliminarily designed, and costed:

1. Conventional Activated Sludge Plant - Consists of primary clarifiers, aeration basins, secondary clarifiers, chlorine contact chamber and sludge beds as well as pretreatment listed in 2.

2. Extended Aeration Pond - Activated sludge utilizing earthen basins, secondary clarifier, chlorine contact chamber, sludge drying beds and necessary pretreatment facilities such as grit removal, bar screens and flow metering.

2a. Extended Aeration Racetrack - Includes normal pretreatment processes listed above along with a brush aerated circulating racetrack, secondary clarifier and sludge drying bed.

3. Aerated Lagoon - Includes costs for grit removal, bar screen and flow meter, aeration to provide oxygen for B.O.D. reduction in the first lagoon, a secondary polishing pond, flotation thickener, and chlorine contact chamber.

4. Biological Contractor (Biosurf Process) - Includes the normal pretreatment components of grit removal, bar screen, flow meter and splitter box. After the above pretreatment bio-surf units, secondary clarifier chlorine contact chamber, and sludge beds are included.

5. Irrigation - Costs include a second cell to the present lagoon, chlorination, a storage reservoir located in Center draw 3.5 miles east of the present lagoon, irrigation by center pivot sprinklers on land southeast of Buffalo.

Assessment of Alternatives

All of the six preliminary design alternatives were costed for two different flow criteria as follows:

1. With infiltration/inflow remaining in the wastewater collection system. This amounts to 2.85 MGD (Average Daily Flow) in 1995.

2. With 60 percent of the infiltration/inflow removed from the wastewater collection system. This amounts to 2.22 MGD (Average Daily Flow) in 1995.

Cost comparisons are shown in Table 62 excluding the irrigation treatment process.

TABLE 62

Buffalo Wastewater Treatment Alternatives

Ranking of Present Worth[1]

Treatment Process	20-Year Treatment Present Worth Cost With I & I Rehab.	20-Year Treatment Present Worth Cost Without I & I Rehab.
Aerated Lagoon	2,202,000	1,988,000
Extended Aeration	2,745,000	2,560,000
Biological Contractor	2,812,000	2,993,000
Conventional Activated Sludge Plant	3,167,000	3,388,000

[1] Not including land costs.

Source: Buffalo, Wyoming Wastewater Facility Plan, Step 1, January, 1977, VTN Engineers, Planners, Surveyors.

Environmental Assessment

The following is a list of expected effects on the local environs caused by Buffalo and its proposed wastewater treatment system by 1985.

a. Approximately 17,500 people are expected to reside in the immediate vicinity of Buffalo.

b. The above 17,500 people are expected to utilize 6.7 cubic feet per second (cfs) of domestic water.

c. Wastewater flows from the above population will reach 4.3 cfs or 7 percent of the average yearly stream flow in Clear Creek.

d. A pollutant load of approximately 4750 pounds/day of 5-day biological oxygen demand (B.O.D.) will be received at the treatment facility in 1985.

e. At the proposed treatment level of 30/30/200 approximately 713 pounds/day of $B.O.D._5$ or 15 percent of the above pollutant load will be passed on to the stream.

f. The coliform count will be reduced to acceptable levels through the use of chlorination or other means of disinfection.

g. Attraction of population and commercial growth.

h. Improved stream water quality.

i. Improved groundwater quality.

j. Reduced nuisance odors
k. Improved aquatic and wildlife habitat.

Selection of Alternative

Major conclusions reached in the Facility Plan were as follows:

1. I and I rehabilitation is not cost effective.

2. Aerated lagoons are the recommended treatment.

3. A 3 stage constriction plan is recommended:
   - Stage 1 - (immediate) construct a 3-cell aerated lagoon
   - Stage 2 - Upgrade the 3-cell lagoon system to provide storage and intermittent discharge for the purposes of algae control.
   - Stage 3 - Expand all of the treatment systems to provide for the ultimate design population.

4. Plant relocation shows no definite cost advantage. Therefore, the final decision for plant relocation would be at the descretion of the City.

The selected alternate and phasing program, as recommended, is shown in Table 63.

TABLE 63

Aerated Lagoon System

Estimated Construction Costs by Stage[1]

Unit	Stage 1	Stage 2	Stage 3	Total
Preliminary Treatment	14,000	0	4,000	18,000
Aeration Ponds & Equipment	224,000	188,000	238,000	650,000
Chlorine Basin & Equipment	0	89,000	25,000	114,000
Lab-office	50,000	0	0	50,000
Total	288,000	277,000	267,000	832,000

[1] Not including land costs.

Source: Buffalo, Wyoming Wastewater Facility Plan, Step 1, January, 1977, VTN Engineers, Planners, Surveyors, p. 24.

The estimated operation and maintenance costs during Stage 1 is $13,200 annually during Stage 2, $53,000 annually and during Stage 3, $78,400 annually.

Clearmont

Existing Wastewater Facilities

Collection Facilities -
The existing wastewater collection system for the Town of Clearmont consists of 8-inch gravity lines carrying sewage to the treatment facility.

Existing Treatment Facilities -
The existing wastewater treatment facility consists of a two-cell conventional stabilization pond (lagoon) located south of the Town of Clearmont. The physical characteristics of the facility are as follows:

TABLE 64

Treatment Facility Characteristics

Berm Elevation	3885.0
Water Surface Elevation	3882.0 (max.)
Bottom Elevation	3877.0
Berm Width	10 feet
Side Slopes	
Inner	3:1
Outer	2:1
Surface Area	1.5 acres
Operating Depth	5.0 feet (max.)
Design Capacity	150 people

Source: EPA 208 Wastewater Facility Planning, Johnson and Sheridan Counties, 201 Facilities Plan, Interim Report, VTN Engineers, Planners, Surveyors, p. VI-4

It should be noted that, with the present population of 182 people, the facility is undersized according to the standards of the Department of Environmental Quality pertaining to surface area per capita. Even if the facility met this design criterion it would not be capable of producing an effluent that could continually meet the applicable discharge standards.

The wastewater treatment facility of the Town does not presently discharge, but it has been concluded that the pond is probably percolating into the groundwater table.

The elevation of the berm of the pond is approximately seven feet above the level of the surrounding flood plain adjacent to Clear Creek. It appears highly unlikely that the facility would be subject to flooding.

Projected Wastewater Loads

The Town of Clearmont has a projected year 2000 population amounting to 345 persons. The per capita design flow utilized for analysis amounts to 125 gallons per capita per day (GPCD) plus an infiltration/inflow rate of 29,100 gallons per day, resulting in a total projected wastewater flow of 72,300 gallons per day.[1]

Alternatives

Five basic alternative wastewater treatment methods were considered for this incorporated community. These methods were as follows:

Alternative 1 - Conventional Stabilization Pond -

The 3-cell conventional stabilization pond was analyzed on the basis of design of providing a surface area of 0.01 acre per capita for the first cell and a detention volume of 30 days each for the second and third cells. The first requirement is the standard for a conventional pond to achieve secondary treatment and the latter is to provide for algae control with intermittent discharge.

The Environmental Protection Agency has recognized the economic advantages of stabilization ponds (lagoons) for small communities. Although algae produced in lagoons prohibits the effluent from meeting secondary treatment standards, the algae has substantially different characteristics than solids from other treatment processes and are not environmentally objectionable. As a result of this, the Environmental Proection Agency has amended their effluent quality standards for suspended solids to permit the use of properly designed stabilization ponds by communities having a wastewater discharge of less than two million gallons per day. Due to this, the conventional stabilization pond is considered as an alternative herein, although it should be noted that a facility of this type cannot provide efficient organic removal during the cold winter months in this area. The system is, however, evaluated for comparison purposes.

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[1] PRAPO, EPA Wastewater Facility Planning, Johnson and Sheridan Counties, 201 Facilities Plans - Interim Report, VTN Engineers, Planners, Surveyors, p. VI-6.

Alternative 2 - Aerated Lagoon -

The basis of design for the 3-cell aerated lagoon was for a three-day detention time in the first cell for aeration, nine days detention in the second cell for sedimentation, and a third cell consisting of two parallel cells of 30 days detention each for polishing and algae control by intermittent discharge.

Alternative 3 - Extended Aeration Plant -

The extended aeration (package) plant is comprised of a factory fabricated waste treatment plant which can be shipped intact to the site, installed on a constructed foundation and be made operational with the necessary exterior piping and electrical service connections.

Alternative 4 - Land Application -

Land application (irrigation) as an alternative would require a two-cell facility, the first consisting of a conventional pond to provide biological treatment and sedimentation and the second being a storage basin with a six-month detention volume for the non-irrigating season. Effluent from the facility would be pumped to the area to be irrigated. Irrigation water could be sold to nearby agricultural users.

Alternative 5 - Controlled Discharge Pond -

The 3-cell controlled discharge pond was analyzed on the basis of design of providing a surface area of 0.01 acres per capita for the first cell and a detention volume of 90 days each for the second and third cells. The first requirement is the standard for a conventional pond to achieve secondary treatment and the latter is to provide storage for the winter months when secondary treatment cannot be achieved as well as to provide for algae control by intermittent discharge.

Assessment of Alternatives

The alternatives for Clearmont were first assessed for present worth value without land costs as shown in Table 65. The aerated lagoon is recommended as the most cost-effective alternative recognizing that while the conventional stabilization pond is economically more feasible, it has inherent limitations in its treatment effectiveness which would lead to adverse environmental effects and that it cannot consistently meet effluent standards. The controlled discharge pond is equally cost-effective to the aerated lagoon when land costs are considered, but maintains aesthetic problems.

TABLE 65

Present Worth of Treatment Alternatives[1]

Alternative	Costs
3-cell Conventional Stabilization Pond	
Capital Cost	
Construction Cost	$ 105,000
Incidental Costs	26,300
	131,300
Present Worth of operation & maintenance cost	90,800
Total Present Worth:	$ 222,100
3-cell Aerated Lagoon	
Capital Cost	
Construction Cost	152,000
Incidental Costs	38,000
	190,000
Present Worth of operation & maintenance cost	191,900
Total Present Worth:	$ 381,900
Land Application	
Capital Cost	
Construction Cost	158,000 (avg.)
Incidental Costs	39,500
	$ 197,500
Present Worth of operation & maintenance cost	186,100
Total Present Worth:	$ 383,600
Extended Aeration	
Capital Cost	
Construction Cost	133,600
Incidental Costs	33,400
	$ 167,000
Present Worth of operation & maintenance cost	381,500
Total Present Worth:	$ 548,500
3-Cell Controlled Discharge Pond	
Capital Cost	
Construction Cost	177,200
Incidental Cost	44,300
	$ 221,500
Present Worth of operation & maintenance cost	138,500
Total Present Worth:	$ 360,000

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[1] Not including land costs

Source: PRAPO EPA 208 Eastewater Facility Planning, Johnson and Sheridan Counties, 201 Facilities Plan-Interim Report, VTN Engineers, Planners, Surveyors, p. VI-12

Implementation of the Clearmont wastewater management program can be undertaken in two stages. This program of implementation is briefly defined as follows:

Stage 1 - 1st Priority (Near Future) -
Upgrade the existing facility to provide a three-day detention aeration basin, a nine-day detention sedimentation basin and utilize the remaining volume of the pond to provide a 24-day detention polishing pond. The detention times given are based on the ultimate design flow of 127,500 gallons per day. This construction would provide adequate treatment for future effluent standards until such time that limitations on algae control are reinstated which is expected to be in 1985.

Stage 2 - 2nd Priority (Future) -
Expand the upgraded facility to provide an additional 36-day detention volume for two 30-day polishing ponds to accommodate the ultimate design flow and add chlorination facilities for disinfection. This stage will provide a treatment facility capable of meeting the projected growth requirements until the year 2000.

Financing -
Financing of the proposed wastewater treatment facilities program, as discussed below, relates to the preparation of contract documents and to the construction of the facilities.

The estimated financial requirements for the program are as follows:

1. Capital Investment

Stage 1	$ 114,000
Stage 2	76,000
Stages 1 & 2	$ 190,000

2. Annual Operation and Maintenance

Stage 1	$ 14,300
Stage 2	16,900
Stages 1 & 2	$ 31,200

3. Bond Debt Service

   Annual payment of 25 percent of capital investment at 6 1/8 percent for 20 years

Stage 1	$ 2,500

Stage 2	1,700
Stages 1 & 2	$ 4,200

The estimated bond debt service costs are based on a program of federal funding whereas the Town's share of the capital costs amounts to 25 percent of the total.

Land acquisition costs have not been included in this evaluation because they are not eligible costs under an Environmental Protection Agency grant program. Land acquisition would not be required for the extended aeration plant. Additional land required for the aerated lagoon would amount to approximately 1.5 acres while both the conventional pond and controlled discharge pond would require about 10.5 additional acres. The land application process would require land acquisition of approximately 14 acres. Using a land cost of $3,250, which is an average value for transactions which have taken place in this area, the relative rankings and the present worth of the alternatives including land acquisition are as follows:

Conventional Stabilization Pond	$ 256,200
Aerated Lagoon	386,800
Controlled Discharge Pond	394,100
Land Application Process	429,100
Extended Aeration Plant	548,500

It should be noted that the costs for the aerated lagoon and the controlled discharge pond are within a range of two percent which, for the accuracy expected at this level of estimating, make them virtually economically identical. Table 66 provides a relative ranking of the alternatives.

Environmental Assessment

The impact of the treatment alternatives in all cases results in an improvement to the environment with an increase in both surface and groundwater quality and a decrease in odor pollution. The exceptions are that during periods of extreme cold the conventional stabilization pond would not produce an effluent meeting EPA standards and the stabilization pond and land application processes would periodically produce odors.

TABLE 66

Relative Ranking of Alternatives

Concept	Conventional Stabilization Pond	Aerated Lagoon	Extended Aeration	Land Application	Controlled Discharge Pond
Economics	5	4	1	2	3
Adaptability	3	4	5	1	2
Environmental Concepts	3	5	5	4	4
Public Input	*	*	*	*	*
Composite	3.7	4.3	3.7	2.3	3.0

* Public input had not been substantially evaluated at this point in the Facility Planning Process.

NOTE: A ranking of 5 is best.

Source: PRAPO EPA 208 Wastewater Facility Planning, Johnson and Sheridan Counties, 201 Facilities Plan-Interim Report, VTN Engineers, Planners, Surveyors, p. VI-18.

Selection of Alternative

It is recommended that the Town of Clearmont proceed with implementation of a plan to upgrade the existing wastewater treatment facilities to provide a 3-cell aerated lagoon and, with acceptable administrative and operational staffs, to provide the operation and maintenance functions necessary to meet the Environmental Protection Agency's effluent quality standards. Administrative and operations and maintenance staff requirements are estimated to be about 920 man-hours per year which is slightly less than one-half time for one person.

Dayton

Existing Wastewater Facilities

Existing Collection Facilities -
The existing wastewater collection system of the Town of Dayton consists of approximately 25 percent 6-inch and 75 percent 8-inch gravity lines and an 8-inch gravity line from the Town to the treatment facility.

Existing Treatment Facilities -
The existing wastewater treatment facility consists of a two-cell conventional stabilization pond (lagoon) located east of the Town of Dayton. The physical characteristics of the facility are as follows:

TABLE 67

Treatment Facility Characteristics

Berm Elevation	4644.0
Water Surface Elevation	4641.0 (max.)
Bottom Elevation	4636.0
Berm Width	8 feet
Side Slopes	
Inner	5:1
Outer	3:1
Surface Area	2.5 acres
Operating Depth	5.0 feet (max.)
Design Capacity	250 people

Source: EPA 208 Wastewater Facility Planning, Johnson and Sheridan Counties, 201 Facilities Plans - Interim Report, VTN Engineers, Planners, Surveyors, p. VIII-4.

With the present population of 550 people, the facility is undersized according to the standards of the Department of Environmental Quality pertaining to surface area per capita. However, even if the facility met this design criterion it would not be capable of producing an effluent that could continually meet the standards previously discussed. The wastewater treatment facility of the Town does not presently discharge but probably percolates into underlying groundwaters.

The elevation of the berm of the pond is approximately 16 to 20 feet above the normal water level of the Tongue River and six to eight feet above the south bank of the river. It appears highly unlikely that the facility would be subject to flooding.

Projected Wastewater Loads

It is projected that the Town of Dayton will record a projected population of 1,170 by the year 2000. In utilizing a projected rate of flow of 125 gallons per capita per day by 1995, it is projected that a design flow of 143,600 gallons per day will be recorded.

Alternatives

The alternatives proposed for Dayton were the same as those for Clearmont. These included: Conventional Stabilization Pond, Aerated Lagoon, Extended Aeration Plant, Land Application, and Controlled Discharge Pond.

Assessment of Alternatives

The present worth of the Dayton treatment alternates are listed in the following table.

TABLE 68

Present Worth of Treatment Alternatives[1]

Alternatives	Costs
3-cell Conventional Stabilization Pond	
Capital Cost	
Construction Cost	$ 133,600
Incidental Costs	33,400
	167,000
Present worth of operation & maintenance cost	121,500
Total Present Worth:	$ 288,500
3-cell Aerated Lagoon	
Capital Cost	
Construction Cost	208,400
Incidental Costs	52,100
	$ 260,500
Present worth of operation & maintenance cost	191,900
Total Present Worth:	$ 452,400
Land Application	
Capital Cost	
Construction Cost	$ 195,900 (avg.)
Incidental Costs	49,000
	244,900
Present worth of operation & maintenance cost	216,900
Total Present Worth:	$ 461,800

Table 68 continued

Extended Aeration	
Capital Cost	
Construction Cost	$ 198,800
Incidental Costs	49,700
	248,500
Present worth of operation & maintenance cost	381,500
Total Present Worth:	$ 630,000
3-cell Controlled Discharge Pond	
Capital Cost	
Construction Cost	$ 243,500
Incidental Costs	60,900
	$ 304,400
Present worth of operation & maintenance cost	211,200
Total Present Worth:	$ 515,600

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[1] Not including land costs.

Source: PRAPO EPA 208 Wastewater Facility Planning, Johnson and Sheridan Counties, 201 Facilities Plan-Interim Report, VTN Engineers, Planners, Surveyors, p. VII-12.

Another method of evaluating the relative ranking of the alternatives as related to the selection of the recommended wastewater management plan is summarized in Table 69.

TABLE 69

Relative Ranking of Alternatives

Concept	Conventional Stabilization Pond	Aerated Lagoon	Extended Aeration	Land Application	Controlled Discharge Pond
Economics	5	4	1	3	2
Adaptability	3	4	5	1	2
Environmental Concepts	3	5	5	4	4
Public Input	*	*	*	*	*
Composite	3.3	4.3	3.7	2.7	2.7

* Public input had not been substantially evaluated at this point in the Facility Planning Process.

NOTE: A ranking of 5 is best.

Source: PRAPO EPA 208 Wastewater Facility Planning, Johnson and Sheridan Counties, 201 Facilities Plan-Interim Report, VTN Engineers, Planners, Surveyors, p. VII-7.

This ranking is based on a rating of five for the most desirable alternative and a descending order of ratings for the less desirable alternatives. The method does not allow for a weighting of the relative values of the various concepts.

Environmental Assessment

The environmental assessment for Dayton is identical to that presented for Clearmont; all of the alternatives would result in an improved environment, however, the stabilization pond and land application would periodically produce odors.

Selection of Alternative

It is recommended that the Town of Dayton proceed with implementation of a plan to upgrade the existing wastewater treatment facilities to provide a 3-cell aerated lagoon and, with acceptable adminstrative and operational staffs, to provide the operation and maintenance functions necessary to meet the Environmental Protection Agency's effluent quality standards. Administrative and operations and maintenance staff requirements are estimated to be approximately 920 man-hours per year which is slightly less than one-half time for one person.

The aerated lagoon is recommended as the most cost-effective alternative recognizing that while the conventional stabilization pond is economically more feasible, it has inherent limitations in its treatment effectiveness which would lead to adverse environmental effects and that it cannot consistently meet effluent standards. The land application process and controlled discharge pond are also less desirable environmentally. Economic comparability is also less favorable for the latter two when land acquisition costs are considered.

Implementation of the Dayton wastewater management program can be undertaken in two stages. This program of implementation is briefly defined as follows:

Stage 1 - 1st Priority (Near Future) -
Upgrade the existing facility to provide a three-day detention aeration basin, a nine-day detention sedimentation basin and utilize the remaining volume of the pond to provide a 45-day detention polishing pond. The detention times given are based on the ultimate design flow of 146,300 gallons per day. This construction would provide adequate treatment for future effluent standards until such time that limitations on algae control are reinstated. This is expected to be in the year 1985.

Stage 2 - 2nd Priority (Future) -
Expand the upgraded facility to provide an additional 15-day detention volume for two 30-day polishing ponds to accommodate the ultimate design flow and add chlorination facilities for disinfection. This stage will provide a treatment facility capable of meeting the projected growth requirements until the year 2000.

Financing -
Financing of the proposed wastewater treatment facilities program, as discussed herein, relates to the preparation of contract documents and to the construction of the facilities.

The estimated financial requirements for the program are as follows:

1. Capital Investment

Stage 1	$ 183,100
Stage 2	77,400
Stages 1 & 2	$ 260,500

2. Annual Operation and Maintenance

Stage 1	$ 14,300
Stage 2	16,900
Stages 1 & 2	$ 31,200

3. Bond Debt Service

Annual payment on 25 percent of capital investment at 6 1/8 percent for 20 years

Stage 1	$ 3,700
Stage 2	2,200
Stages 1 & 2	$ 6,900

The estimated bond debt service costs are based on a program of Federal funding whereas the Town's share of the capital costs is estimated to amount to 25 percent of the total.

Gillette

Existing Wastewater Facilities

Existing Collection System -

The central collection system for the City of Gillette consists of approximately 23.4 miles of 8-inch main, 3.3 miles of 10-inch main, 1.6 miles of 12-inch main, 212 miles of 15-inch main, 0.3 miles of 18-inch main, and 2.5 miles of 21-inch sanitary sewer mains. One lift station serves a portion of the northwest quadrant of the City. Several small privately owned lift stations also pump sewage to the public system. There are approximately 800 manholes in the public system. The original collection system was installed prior to 1940 and is composed primarily of vitrified clay pipe (VCP) with brick manholes.

The capacity of the existing outfall system is limited by the size of the gravity outfall installed after 1972. Based on the least slope installed, the full flow capacity is calculated as 2801.4 gallons per minute. Based on 100 gallons per day per capita and a peak flow 2.5 times the average, the design flow per capita is .17 gallons per minute and the outfall capacity is equivalent to about 16,500 persons.

The capacity of the new Donkey Creek Interceptor line from the wastewater treatment plant to its junction amounts to 5821 gallons per minute. The branch lines entering here will carry a flow in excess of that, consequently, 5821 gallons per minute is the limiting flow condition. The interceptor maximum capacity is equivalent to about 33,500 persons.

Existing Treatment Plant -

The existing wastewater treatment plant for the City of Gillette commenced operation in March, 1974. This facility utilizes the activated sludge processes and discharges to Stonepile Creek which lies in the Belle Fourche River Basin.

Raw wastewater enters the plant through a hand-cleaned bar screen. After screening, the flow passes through two inoperative comminutors, installed in parallel. A Parshall flume is utilized to measure the flow after comminution. Supernatant from the digesters and return sludge from the secondary clarifiers are gaged through similar flumes prior to joining the raw influent. This composite flow is then divided between duplicate aeration tanks each equipped with a fixed-mounted surface turbine aerator. The treatment plant does not include separate grit removal facilities. Instead, each circular aeration basin contains a hopper bottom and grit sump at the center from which grit can be pumped periodically to a grit pit. Effluent from the aeration basins flows to two circular center-feed secondary settling basins. The sludge is forced to a center well from which it is pumped to the headworks of the plant where it is combined with the influent. Although flow through the previously-described units is by gravity, effluent from the secondary clarifiers must be pumped to the polishing pond which is the final unit of the treatment system.

The process waste sludge and scum from the final clarifiers are discharged to the aerobic digesters where, through long-term aeration, they are decomposed to an inert, humus-like material. Sludge can be either pumped to a temporary sludge lagoon or hauled away and spread over land adjacent to the plant site.

Projected Wastewater Loads

The projected 1997 design population for the City of Gillette amounts to 40,000 persons. Based upon data from existing treatment plant records, an average wastewater hydraulic loading of 100 gallons per capita per day (GPCD) was utilized in calculating design flows. This unit value includes domestic as well as infiltration, inflow, commercial and industrial flows. Also from an evaluation of existing data it would appear that flows could be expected to vary from 60 to 250 percent of the average. Therefore, the treatment plant should be sized for an average unit flow of 100 GPCD and be capable of handling peak flows of up to 250 GPCD. Accordingly, the nominal capacity of the wastewater treatment facilities would be 4.00 million gallons per day (MGD). The estimated peak and minimum flows along with the design average flows for 1977, 1987, and 1997 are presented in Table 70.

TABLE 70

Design Wastewater Loadings, Gillette, Wyoming

	1977	1987	1997
Estimated Population	18,500	36,000	40,000
Hydraulic Loading mgd			
24-hour Average[1]	1.85	3.60	4.00
Peak[2]	4.63	9.00	10.00
Minimum[3]	1.11	2.16	2.40
BOD_5 Loading, lb/day			
24-hour average[4]	3,145	6,120	6,800
SS Loading, lb/day			

Table 70 continued

24-hour average[5]	3,700	7,200	8,000

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[1] Based on unit flow of 100 gallons/capita/day

[2] Based on 250 percent of average flow

[3] Based on 60 percent of average flow

[4] Based on 0.17 lb BOD_5/capita/day

[5] Based on 0.20 lb SS/capita/day

Source: EPA 201 Facilities Plan for the City of Gillette, Wyoming, Plains Engineering, p. IV-9.

Alternatives

Based on findings in the Gillette Facilities Plan, several wastewater treatment processes are capable of producing an effluent meeting the limitations set forth in the Gillette discharge permit. These methods are summarized as follows:

Land Application -

Three general methods have been used to apply raw or treated wastewater to the land: 1) irrigation; 2) infiltration-percolation; and 3) overland flow.

Stabilization Ponds (STP) -

This method of wastewater treatment consists of relatively shallow ponds through which sunlight can readily penetrate. Waste stabilization is carried out by a mutually-beneficial relationship between bacteria and algae.

Trickling Filters (TrF) -

This process consists of a fixed bed of either course stone or plastic sheets engineered to provide a large quantity of surface area per unit volume along with enough clear openings to insure adequate ventilation for micro-organisms which grow on the media and degrade the organic materials in wastewater.

Rotating Biological Contactors (RBC) -

This treatment method consists of a series of closely-spaced vertical discs mounted on a horizontal shaft. The discs are submerged to a depth of about one-half their diameter in a basin containing wastewater. As the discs rotate, the biomass adhering to the surface is alternately wetted and aerated. This allows aerobic bacteria to thrive by feeding on the organic matter in the wastewater.

Activated Sludge (AS) -
The activated sludge (AS) process utilizes bacteria in liquid suspension to oxidize the carbonaceous matter in wastewater.

Effluent Reuse -
Based on the limitations stipulated for Gillette, the treatment plant effluent should be suitable for reuse as cooling water, groundwater recharge and irrigation. A contract does exist between the Black Hills Power and Light Company and the City of Gillette in which the Company has agreed to purchase the effluent from the treatment plant for use as cooling water. This arrangement represents an almost ideal beneficial use of the effluent.

Upgrading Existing Treatment Plant -
Although it has experienced certain operational problems, the existing wastewater treatment plant is only approximately two years old. Consequently, incorporating any future treatment system with the existing system should represent a significant economic asset in construction of future improvements. There are several alternative methods by which the existing plant could be utilized in meeting future increases in loading and simultaneously produce an effluent within prescribed limitations.

Assessment of Alternatives

All of the previously discussed treatment methods for Gillette are capable of producing an effluent meeting the prescribed limitations. Additionally, these alternatives are generally comparable in ease of operation, ability to withstand shock loadings, and effluent variability. Based on these factors, preliminary selection of the most suitable treatment alternative can be made primarily on the basis of cost.

The following table compares the costs of four alternative methods of treating the wastes emanating from the Gillette area. Each alternative utilizes the activated sludge method of liquid treatment, one for a new plant and two for upgrading the existing plant. Activated sludge was chosen as the best method of liquid treatment based upon its comparative low cost, excellent treatment performance, flexibility to accept different modes of operation if necessary, and its familiarity to plant operators.

TABLE 71

Treatment Alternative Cost Comparisons[1]

A	B	C	D	
Treatment Alternate	Capital Cost	Capital Recovery[2]	Annual O & M	Total (C + D)
New Activated Sludge Plant With Aerobic Sludge Digestion	$ 4,751,300	$ 414,220	$ 304,000	$ 718,220
Upgrade Existing Plant and Use Aerobic Sludge Digestion	4,197,920	365,980	304,000	669,980

[1] Exclusive of land costs

[2] Twenty years at 6 percent interest, CRF = .08718

Source: EPA 201 Facilities Plan for the City of Gillette, Wyoming, Plains Engineering, p. IX-3.

Environmental Assessment

The degree of treatment and methods of final disposal for each alternate are consistent with State and Federal requirements, and any effluent discharged during or after construction of the facility should not deteriorate the classification of the adjacent surface waters. The proposed location of the facility does not present a nuisance, is not in a designated flood zone, will not interfere with other activities, nor is the project expected to be controversial.

The appearance of the plant site will be improved aesthetically, and any area disrupted by construction will be restored to an equal or better condition. The present plant location and the areas adjacent to it have no near term potential for residential or commercial activities. In addition, this proposed project will not displace any person, nor will it significantly disrupt an existing sewer system, transportation system, or other necessity.

Selection of Alternative

From preceding Table 71, it can be seen that upgrading the existing activated sludge plant, utilizing existing units, is the least expensive alternative by $13,380 in annual costs and $6,800 in capital costs.

The selected alternate is comprised of the following treatment units:

1. New Preliminary Treatment: Screening, Grit Removal, Comminution, and Flow Gaging.
2. Two (2) New Primary Clarifiers, each 65' Dia x 8' SWD.
3. Two (2) New Rectangular Aeration Basins, each 75' x 60' x 15' deep.
4. One (1) New Secondary Clarifier, 75' Dia x 12' SWD. Conversion of two (2) Aeration Tanks and Alteration of Two (2) Clarifiers, each 50' Dia x 12' SWD.
5. One (1) Chlorine Contact Basin, 65' x 33' x 8' Liquid Depth.
6. Alteration of two (2) Aerobic Digestors to two (2) Thickeners, 50' Dia.
7. Abandon One (1) Thickener (Could be utilized later).
8. Two (2) New Aerobic Digestion Units, each 20' by 92'x 16' Deep.
9. Five (5) New Sand Drying Beds, each 20' x 200'.

The existing polishing pond will be used as a Dechlorination Pond. Also, preliminary reviews of the hydraulic profile indicate the necessity of pumping, possibly between preliminary and primary treatment. A more detailed site investigation would be required to establish the location of a pumping facility. The treated liquid waste, up to 1.6 million gallons per day, will be sold to Black Hills Power and Light in accordance with the existing City contract with BHP & L Company.

Sludge Handling

Several methods of sludge treatment and disposal were analyzed in the facilities plan. Sludge thickening to reduce the total volume of sludge by removing some of the water prior to digestion improves not only the digester performance, but also improves clarifier efficiency. Sludge digestion, which can be either aerobic or anaerobic, follows thickening. The choice of the type of digestion to be utilized is dependent upon several factors presently being analyzed by the City of Gillette but aerobic digestion is the preferred option. After digestion, sludge may be spread on land as a soil conditioner, sand dryed and disposed of in a land fill, or filtered and disposed of. Vacuum filtration is a costly system as well as being difficult to operate. Thus, it was not considered.

Kaycee

Existing Wastewater Facilities

Existing Collection Facilities -
The existing wastewater collection system of the Town of Kaycee consists of approximately 40 percent 6-inch and approximately 60 percent 8-inch gravity lines, and an 8-inch outfall line from the Town to a lift station located on the south bank of the Middle Fork of the Powder River. The wastewater is pumped from this location into the treatment facility.

Existing Treatment Facilities -
The existing wastewater treatment facility consists of a single-cell conventional stabilization pond (lagoon) located south of the Town of Kaycee. Effluent from the lagoon is discharged into the Middle Fork of the Powder River. The physical characteristics of the facility are shown in Table 72.

TABLE 72
Treatment Facility Characteristics

Berm Elevation	4644.0
Water Surface Elevation	4641.0 (max.)
Bottom Elevation	4636.0
Berm Width	8 feet
Side Slopes	
Inner	5:1
Outer	3:1
Surface Area	2.5 acres
Operating Depth	5.0 feet (max.)
Design Capacity	250 people

Source: EPA 208 Wastewater Facility Planning, Johnson and Sheridan Counties, 201 Facilities Plans - Interim Report, VTN Engineers, Planners, Surveyors p. III-4.

With the present population of 390 persons, the facility is undersized relative to the standards of the Department of Environmental Quality pertaining to surface area per capita. Even if the facility met this design criterion it would not be capable of producing an effluent that could continually meet the applicable discharge standards.

Projected Wastewater Loads

The facilities plan for Kaycee projects a year 2000 design population of 1,020 for the community of Kaycee. Design flows for the evaluation of wastewater treatment consisted of a contribution of 125 gallons per day, including allowable infiltration/inflow. This results in an ultimate average daily flow of 127,500 GPD anticipated by the year 2000.

Alternatives

The alternatives suggested for Kaycee are the same as for those presented for Clearmont including: Conventional Stabilization Pond, Aerated Lagoon, Extended Aeration Plant, Land Application, and Controlled Discharge Pond.

Assessement of Alternatives

The present worth method of economic assessment of each treatment alternative is shown in Table 73.

TABLE 73

Present Worth of Treatment Alternatives[1]

Alternative	Cost
3-cell Conventional Stabilization Pond	
Capital Cost	
Construction Cost	$ 134,200
Incidental Costs	33,600
	167,800
Present worth of operation and maintenance cost	119,200
Total Present Worth:	$ 287,000
3-cell Aerated Lagoon	
Capital Cost	
Construction Cost	$ 188,000
Incidental Costs	47,000
	235,000
Present worth of operation and maintenance cost	193,000
Total Present Worth:	$ 428,000
Land Application	
Capital Cost	
Construction Cost	$ 188,800 (avg.)
Incidental Csots	47,200
	236,000
Present worth of operation and maintenance cost	214,600
Total Present Worth:	$ 450,600

Table 73 continued

Extended Aeration	
Capital Cost	
Construction Cost	$ 187,000
Incidental Costs	46,800
	233,800
Present worth of operation and maintenance cost	381,500
Total Present Worth:	$ 615,300
3-cell Controlled Discharge Pond	
Capital Cost	
Construction Cost	$ 231,100
Incidental Cost	57,800
	288,900
Present worth of operation and maintenance cost	$ 193,000
Total Present Worth:	$ 481,900

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[1] Not including land costs.

Source: PRAPO EPA 208 Wastewater Facility Planning, Johnson and Sheridan Counties, 201 Facilities Plan-Interim Report, VTN Engineers, Planners, Surveyors, p. III-12 & 13.

A combined method of evaluating the relative ranking of the alternatives as related to the selection of the recommended wastewater management plan is summarized in Table 74.

TABLE 74

Relative Ranking of Alternatives

Concept	Conventional Stabilization Pond	Aerated Lagoon	Extended Aeration	Land Application	Controlled Discharge Pond
Economics	5	4	1	3	2
Adaptability	3	4	5	1	2
Environmental Concepts	3	5	5	4	4
Public Input	*	*	*	*	*
Composite	3.3	4.3	3.7	2.7	2.7

*Public input had not been substantially evaluated at this point in the Facility Planning Process.

NOTE: A ranking of 5 is best.

Source: PRAPO EPA 208 Wastewater Facility Planning, Johnson and Sheridan Counties, 201 Facilities Plan-Interim Report, VTN Engineers, Planners, Surveyors, p. III-17.

This ranking is based on a rating of five for the most desirable alternative and a descending order of ratings for the less desirable alternatives. The method does not allow for a weighting of a relative value of the various concepts.

Environmental Assessment

The environmental assessment for Kaycee is the same as that presented for Clearmont and concludes that all alternates would be an environmental improvement over the existing facility, but the stabilization pond and land application would periodically produce odors.

Selection of Alternative

It is recommended that the Town of Kaycee proceed with implementation of a plan to upgrade the existing wastewater treatment facilities to provide a 3-cell aerated lagoon and, with acceptable administrative and operational staffs, to provide the operation and maintenance functions necessary to meet the Environmental Protection Agency's effluent quality standards. Administrative and operations and maintenance staff requirements are estimated to be about 920 man-hours per year which is slightly less than one-half time for one person. The aerated lagoon is recommended as the most cost-effective alternative recognizing that, while the conventional stabilization pond is economically more feasible, it has inherent limitations in its treatment effectiveness which would lead to adverse environmental effects in that it cannot consistently meet effluent standards. The land application process and controlled discharge pond are also less desirable environmentally. Economic comparability is also less favorable for the latter two when land acquisition costs are considered.

The existing wastewater collection system can be expanded to accommodate the anticipated growth of the Town although the Department of Environmental Quality will probably require that the six-inch diameter mains be replaced with eight-inch pipe. Eight-inch lateral collection lines constructed on the minimum allowable slope maintain the capacity to serve a population of approximately 1,200 people. The Department of Environmental Quality regulations allow for a design capacity of about 1,950 people for eight-inch trunk and outfall lines, not recording extraordinary infiltration/inflow. In either case, the eight-inch wastewater lines are more than adequate for the projected design population. The present lift station will require modification at such time that its capacity will be reached. This can probably be accomplished merely by pump replacement and should be a consideration in the maintenance program for the system.

Implementation of the Kaycee wastewater management program can be undertaken in two stages. This program of implementation is briefly defined as follows:

Stage 1 - 1st Priority (Near Future) -
Upgrade the existing facility to provide a three-day detention aeration basin, a nine-day detention sedimentation basin and utilize the remaining volume of the pond to provide a 40-day detention polishing pond. The detention times given are based on the ultimate design flow of 127,500 gallons per day. This construction would provide adequate treatment for future effluent standards until such time that limitations on algae control are reinstated. This is estimated to be in the year 1985.

Stage 2 - 2nd Priority (Future) -
Expand the upgraded facility to provide an additional 20-day detention volume for two 30-day polishing ponds to accommodate the ultimate design flow and add chlorination facilities for disinfection. This stage will provide a treatment facility capable of meeting the projected growth requirements until the year 2000.

Financing -
Financing of the proposed wastewater treatment facilities program includes the preparation of contract documents and the construction of the facilities.

The estimated financial requirements for the program are as follows:

1. Capital Investment

Stage 1	$ 156,100
Stage 2	78,900
Stages 1 & 2	$ 235,000

2. Annual Operation and Maintenance

Stage 1	$ 14,300
Stage 2	16,900
Stages 1 & 2	$ 31,200

3. Bond Debt Service

Annual payment of 25 percent of capital investment at 6 1/8 percent for 20 years

Stage 1	$ 3,400
Stage 2	1,800

Stages 1 & 2	$ 5,200

The estimated bond debt service costs are based on a program of federal funding whereas the Town's share of the capital costs is estimated to amount to 25 percent of the total.

Ranchester

Existing Wastewater Facilities

Existing Collection Facilities -
The existing wastewater collection system of the Town of Ranchester consists of 8-inch gravity collection lines and a 10-inch outfall line from the Town to the treatment facility. A trailer park at the west edge of the Town is served by a lift station which pumps into the gravity system.

Existing Treatment Facilities -
The existing wastewater treatment facility consists of a two-cell conventional stabilization pond (lagoon) located east of the Town of Ranchester. Effluent from the lagoon is discharged into the Tongue River. The physical characteristics of the facility are shown in Table 75 .

TABLE 75

Treatment Facility Characteristics

Berm Elevation	99.0
Water Surface Elevation	95.7 (max.)
Bottom Elevation	91.5
Berm Width	10 feet
Side Slopes	
Inner	3:1
Outer	2:1
Surface Area	3.2 acres
Operating Depth	4.2 feet (max.)
Design Capacity	320 people

Source: EPA 208 Wastewater Facility Planning, Johnson and Sheridan Counties, 201 Facilities Plans- Interim Report, VTN Engineers, Planners, Surveyors, p. VIII-4.

With the present population of 420 people, the facility is undersized according to the standards of the Department of Environmental Quality pertaining to surface area per capita. However, even if the facility met this design criterion, it would not be capable of producing an effluent that could continually meet the standards previously discussed.

The elevation of the berm of the pond is somewhat higher than the level of the stream and the surrounding flood plain. Because of the extent of this floodplain, it appears unlikely that the facility would be subject to flooding.

Projected Wastewater Loads

The Ranchester facilities plan projects a year 2000 population amounting to 1,260 persons. Design flows for the evaluation of wastewater treatment alternatives were based on a per-capita domestic wastewater contribution of 125 gallons per day, plus an infiltration/inflow rate of 256,000 GPD. This results in an ultimate average daily design flow of 414,100 GPD which is anticipated by the year 2000.

Alternatives

The treatment alternatives for Ranchester are the same as those explained for Clearmont, including the following: Conventional Stabilization Pond, Aerated Lagoon, Land Application, and Controlled Discharge Pond, and Extended Aeration.

Assessment of Alternatives

The financial assessment of the proposed alternatives, at estimated present worth, is depicted in the following table:

TABLE 76

Present Worth of Treatment Alternatives[1]

Alternative	Cost
3-Cell Conventional Stabilization Pond	
Capital Cost	
Construction Cost	$ 166.500
Incidental Costs	41,600
	208,100
Present worth of operation and maintenance cost	146,500
Total Present Worth:	$ 355,600
3-Cell Aerated Lagoon	
Capital Cost	
Construction Cost	$ 248,600
Incidental Costs	62,200
	310,800

Table 76 continued

Present worth of operation and maintenance cost	211,200
Total Present Worth:	$ 522,000
Land Application	
Capital Cost	
Construction Cost	$ 235,000 (avg.)
Incidental Costs	58,800
	293,800
Present worth of operation and maintenance cost	241,800
Total Present Worth:	$ 535,600
Extended Aeration	
Capital Cost	
Construction Cost	$ 302,700
Incidental Costs	75,800
	378,500
Present worth of operation and maintenance cost	404,100
Total Present Worth:	$ 782,600
3-Cell Controlled Discharge Pond	
Capital Cost	
Construction Cost	$ 324,400
Incidental Costs	81,100
	405,500
Present worth of operation and maintenance cost	265,700
Total Present Worth:	$ 671,200

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[1] Not including land costs

Source: PRAPO EPA 208 Wastewater Facility Planning, Johnson and Sheridan Counties, 201 Facilities Plan-Interim Report, VTN Engineers, Planners, Suveyors, P. VIII-12.

The present worth values of the treatment alternatives are shown in Table 76 and result in the following relative ranking of the alternatives in ascending order:

1. The conventional stabilization pond;
2. The aerated lagoon;
3. The land application process;
4. The controlled discharge pond;
5. The extended aeration plant.

The conventional stabilization pond is notably the most economical for both capital cost and operation and maintenance costs. The aerated lagoon, land application process and controlled discharge pond are within a relatively close cost range.

A comprehensive method of evaluating the relative ranking of the alternatives as related to the selection of the recommended wastewater management plan is summarized in Table 77 .

TABLE 77

Relative Ranking of Alternatives

Concept	Conventional Stabilization Pond	Aerated Lagoon	Extended Aeration	Land Application	Controlled Discharge Pond
Economics	5	4	1	3	2
Adaptability	3	4	5	1	2
Environmental Concepts	3	5	5	4	4
Public Input	*	*	*	*	*
Composite	3.3	4.3	3.7	2.7	2.7

*Public input had not been substantially evaluated at this point in the Facility Planning Process.

NOTE: A ranking of 5 is best.

Source: PRAPO EPA 208 Wastewater Facility Planning, Johnson and Sheridan Counties, 201 Facilities Plan-Interim Report, VTN Engineers, Planners, Surveyors, p. VIII-18.

This ranking is based on a rating of five for the most desirable alternative and a descending order of ratings for the less desirable alternatives. The method does not allow for a weighting of the relative value of the various concepts.

Environmental Assessment

The environmental assessment for Ranchester concludes the same as that given for Clearmont. All alternates would result in an improved environment but stabilization ponds and land disposal would periodically produce odors.

Selection of Alternative

The aerated lagoon is recommended as the most cost-effective alternative recognizing that, while the conventional stabilization pond is economically more feasible, it has inherent limitations in its treatment effectiveness which would lead to adverse environmental effects in that it cannot consistently meet effluent standards. The land application process and controlled discharge pond are also less desirable environmentally. Economical comparability is also less favorable for the latter two when land acquisition costs are considered.

The existing wastewater collection system can be expanded to accommodate the anticipated growth of the Town although a program of rehabilitation will probably be required to eliminate the infiltration/inflow and assure sufficient capacity for future growth. Eight-inch internal collection lines constructed on the minimum allowable slope have the capacity to serve a population of approximately 1,200 persons. The Department of Environmental Quality regulations allow for a design capacity of about 1,950 persons for eight-inch trunk and outfall lines, not maintaining extraordinary infiltration/inflow. In either case, the eight-inch wastewater lines are more than adequate for the projected design population if extraneous flows are eliminated.

Implementation of the Ranchester wastewater management program can be undertaken in two stages. This program of implementation is briefly defined as follows:

Stage 1 - 1st Priority (Near Future) -
Upgrade the existing facility to provide a three-day detention aeration basin, a nine-day detention sedimentation basin and utilize the remaining volume of the pond to provide a 6-day detention polishing pond. The detention times given are based on the ultimate design flow of 146,500 gallons per day. This construction would provide adequate treatment for future effluent standards until such time that limitations on algae control are reinstated. This is expected to be in the year 1985.

Stage 2 - 2nd Priority (Future) -
Expand the upgraded facility to provide an additional 54-day detention volume for two 30-day polishing ponds to accommodate the ultimate design flow and add chlorination facilities for disinfection. This stage will provide a treatment facility capable of meeting the projected growth requirements until the year 2000.

Financing-

Financing of the proposed wastewater treatment facilities program includes the preparation of contract documents and the construction of the facilities.

The estimated financial requirements for the program are as follows:

1. Capital Investment

Stage 1	$ 179,500
Stage 2	131,300
Stages 1 & 2	$ 310,800

2. Annual Operation and Maintenance

Stage 1	$ 14,600
Stage 1	18,900
Stages 1 & 2	$ 33,500

3. Bond Debt Service

Annual payments on 25 percent of capital investments at 6 1/8 percent for 20 years

Stage 1	$ 4,000
Stage 2	2,900
Stages 1 & 2	$ 6,900

The estimated bond debt service costs are based on a program of federal funding whereas the Town's share of the capital costs is estimated to amount to 25 percent of the total.

Sheridan[1]

Existing Wastewater System

Collection System Description -

The sanitary wastewater collection system operates primarily by gravity. Lift stations and force mains have been constructed in several locations within the collection system to serve low lying areas.

The service area wastewater is collected from two major tributary areas. An 18-inch diameter trunk line serves the western portion of the City and is approximately 7,000 feet in length. The larger of the two tributary areas is collected on a 24-, 21-, and 18-inch diameter trunk line. This line is approximately 18,000 feet in length and serves the eastern and southern portions of the City. Both sewer mains serving the two major tributary areas discharge to the treatment plant utilizing a 36-inch outfall main, 280 feet in length.

The existing service area collection system consists of nearly 58 miles of sewer mains varying from 6- to 36- inches in diameter. Of the 58 miles of sewer mains, only 3,500 feet consist of force mains, most of which are located in the South Side Sewer District. Over 73 percent of the collection system is 8-inch diameter pipe, 2 percent is 6-inch diameter and smaller; the remaining 25 percent is 10-inch to 36-inch in diameter. Four major lift stations serve the system.

Wastewater Treatment Plan-

The Sheridan municipal wastewater treatment plant is situated on the east bank of Goose Creek north of State Highway 337. The original plant, constructed in 1939, was considered to be one of the most advanced treatment plants at that time. In 1966 the treatment facilities were expanded and improved. The plant design was upgraded to secondary treatment, with capacity to accommodate average daily biological loads in flows of 2.1 million gallons per day (MGD), and was designed with a hydraulic capacity of 5 million gallons per day. Secondary treatment was achieved by the addition of primary clarifiers and single stage trickling filters. These improvements added the necessary processes to provide an effluent of acceptable quality based on late 1960 water quality standards. The following indicates the unit processes at the plant as it now exists.

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[1] This alternative is considered to obtain advanced treatment (nitrification) above and beyond secondary treatment.

1. Grit Chamber
2. Primary Settling Basins - 2 each
3. Trickling Filters - 2 each
4. Final Settling Basin
5. Sludge Digestion Tanks - nonoperative

The grit chamber unit includes a mechanically cleared screen and screening grinder, grit removal equipment and parshall flume.

Existing equipment at the plant has been well maintained over the years and is in very good condition with the possible exception of the sludge digester. The sludge digester has been converted and used as a sludge holding tank.

Projected Wastewater Loads

The Wastewater Facility Plan for the City of Sheridan indicated that the City will reach a population of approximately 26,000 by the year 1995. This population figure was utilized as a basis for the projected design flows shown in Table 78.

TABLE 78

Projected Wastewater Flows

Alternate Flow Conditions	Quantity
Annual Average Daily Flow (AADF)	
1. With I/I Rehabilitation	2.875 MGD
2. Without I/I Rehabilitation	4.1 MGD
Annual Peak Daily Flow (APDF)	
1. With I/I Rehabilitation	3.65 MGD
2. Without I/I Rehabilitation	5.21 MGD
Instantaneous Peak Flow (IPF)	
1. With I/I Rehabilitation	6.88 MGD
2. Without I/I Rehabilitation	14.03 MGD
Design BOD_{5-20}	300 mg/l
Design SS	300 mg/l

Source: Sheridan, Wyoming Wastewater Facility Plan, Step 1, VTN Engineers, Planners, Surveyors, p. 9-5

Alternatives

The Sheridan Facility Plan addresses two basic processes for improvement of wastewater treatment, including trickling filter and activated sludge improvements. Several alternates have been developed for each of these processes and are shown in accompanying Tables 79 and 80.

TABLE 79

Alternatives for Expansion of Trickling Filtration

Alternative	Design Flow (MGD)	
1-1	2.875	Expand all unit processes, add effluent filtration. Sludge holding, vacuum filtration.
1-2	4.1	Expand all unit processes, add effluent chlorination and effluent filtration. Sludge holding, vacuum filtration.
1-3	2.875	Expand all unit processes, add chlorination and effluent filtration, delete sludge storage, add aerobic digestion and vacuum filtration of sludge.
1-4	4.1	Expand all unit processes, add chlorination and effluent filtration, delete sludge storage, add aerobic digestion and vacuum filtration of sludge.
1-5	2.875	Expand all unit processes, add chlorination and effluent filtration, delete sludge storage, add composting.
1-6	4.1	Expand all unit processes, add chlorination and effluent filtration, delete sludge storage, add composting.

Source: Sheridan, Wyoming Wastewater Facility Plan, Step 1, VTN Engineers, Planners, Surveyors, p. 9-3

TABLE 80

Alternatives for Construction of New Activated Sludge System

Alternative	Design Flow (MGD)	Description
2-1	2.875	Remove trickling filters and sludge holding tank, expand all remaining processes, add aerobic digestion and sludge, activated sludge process and chlorination.
2-2	4.1	Remove trickling filters and sludge holding tank, expand all remaining processes, add aerobic digestion and sludge, activiated sludge process and chlorination.
2-3	2.875	Remove trickling filters and sludge holding tank, expand all remaining processes, add activated sludge process chlorination, effluent and vacuum filtration, and aerobic digestion of sludge.
2-4	4.1	Remove trickling filters and sludge holding tank, expand all remaining processes, add activated sludge process chlorination, effluent and vacuum filtration, and aerobic digestion of sludge.
2-5	2.875	Remove trickling filters and sludge holding tank, expand all remaining processes, add activated sludge process chlorination, and composting. Remove existing vacuum filter system.
2-6	4.1	Remove trickling filters and sludge holding tank, expand all remaining processes, add activated sludge, chlorination, and composting. Remove existing vacuum filter system.
2-7	2.875	Remove trickling filters and sludge holding tank, expand all remaining processes, add activated sludge, chlorination, effluent filtration, and composting. Remove existing vacuum filter system.
2-8	4.1	Remove trickling filters and sludge holding tank, expand all remaining processes, add activated sludge, chlorination, effluent filtration, and composting. Remove existing vacuum filter system.

Source: Sheridan, Wyoming Wastewater Facility Plan, Step 1, VTN Engineers, Planners, Surveyors, p. 9-4

Assessment of Alternatives

Table 81 shows a complete cost assessment for all proposed alternatives, as present worth of capital cost and operation and maintenance.

An alternative of relocating the plant site approximately 2 miles north of the existing site was also explored. The following cost assessments were formulated for relocation of the plant site:

Relocation Alternative #1

Trickling filter plant located two miles north of present plant

Capital Cost of Treatment Plant Items	$ 3,104,140
Capital Cost of two miles 36" Outfall	475,000
Capital Cost of 10 Acres of Land	10,000
Present Worth of 20 Years Operation & Maintenance	1,263,903
Total Present Worth Cost:	$4,853,043

Relocation Alternative #2

Activated sludge plant located two miles north of present plant

Capital Cost of Treatment Plant Items	$ 2,872,280
Capital Cost of two miles 36" Outfall	475,000
Capital Cost of 10 Acres of Land	10,000
Present Worth of 20 Years Operation & Maintenance	1,760,692
Total Present Worth Cost:	$ 5,117,972

A comparison of the relocated trickling filter plant with the expanded trickling filter process at the present plant site (Alternative 1-5) yields an additional $610,809 (present worth basis) for the relocated trickling filter plant on a present worth basis. The cost difference amounts to $1,084,809, considering only the initial capital costs. This one million dollar difference is spread almost equally between transmission line and plant cost.

TABLE 81

Preliminary Total Project Cost Estimates

Alternative Description	Present Worth[1] For Design Without Infiltration 2.875 MGD[2]	Present Worth For Design With Infiltration 4.1 MGD	Cost Difference	Annual Maintenance	Total Capital Cost
1-1 Expand present unit processes, add chlorination & effluent filtration. Use present sludge handling. Convert anerobic digestion to sludge holding tank.	($3,790,181) Two		$ 802,705	$110,421	$2,524,86
1-2 Same as above		$4,592,886		137,795	3,013,89
1-3 Expand present unit processes, add chlorination & effluent filtration, add aerobic digestion of sludge, delete sludge storage	4,102,131 Four		803,751	120,895	2,716,79
1-4 Same as above		4,905,882		148,268	3,206,8
1-5 Expand present unit processes, add chlorination & effluent filtration, delete sludge storage, add composting.	(3,699,234) One		802,431	110,192	2,435,3
1-6 Same as above		4,501,665			2,924,0

TABLE 81 . Continued

Preliminary Total Project Cost Estimates

Alternative Description	Present Worth[1] For Design Without Infiltration 2.875 MGD[2]	Present Worth For Design With Infiltration 4.1 MGD	Cost Difference	Annual Maintenance	Total Capital Cost
2-1 Remove trickling filters and sludge holding tank, expand remaining process. Add aerobic digestion, activated sludge, and chlorination.	$4,531,389		$371,291	$164,248	$2,649,26
2-2 Same as above		$4,902,680		200,526	2,604,85
2-3 Remove trickling filters and sludge holding tank, expand all remaining processes, add activated sludge, chlorination, filtration and aerobic digestion.	4,956,671		733,544	142,669	3,321,82
2-4 Same as above		5,690,215		172,444	3,714,17
2-5 Remove trickling filters and sludge holding tank, expand all remaining processes, add activated sludge, chlorination and composting. Remove existing vacuum filter system.	4,126,388 Five		-(41,570)	153,651	2,365,69
2-6 Same as above		(4,084,818) Three		153,651	2,324,1

TABLE 81 , continued

Preliminary Total Project Cost Estimates

Alternative Description	Present Worth[1] For Design Without Infiltration 2.875 MGD[2]	Present Worth For Design With Infiltration 4.1 MGD	Cost Difference	Annual Maintenance	Total Capital Cost
2-7 Remove trickling filters and sludge holding tank, expand all remaining processes, add activated sludge, chlorination and effluent filtration and composting, remove existing vacuum filter system.	$4,553,504		$730,910	$132,072	$3,040,08
2-8 Same as above		$5,284,414		161,848	3,429,80

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[1] Includes $531,000 rehabilitation cost for I/I.

[2] Costs include 20-year operation and maintenance costs.

Source: Sheridan, Wyoming Wastewater Facility Plan, Step 1, VTN Engineers, Planners, Surveyors, p. 10-7.

In comparing the above relocated activated sludge plant with the activated sludge plant (Alternative 2-6) designed for the existing site yields an additional $1,033,154 on a present worth basis. On an initial capital cost basis the relocated activated sludge plant would cost an additional $1,033,154. As noted above, the one million dollar difference is spread equally between transmission line cost and plant cost.

As noted from the two cost comparisons, relocating a treatment plant two miles north of its present location involves an additional one million dollars in either case.

Environmental Assessment

Alternatives considered included no action, biological treatment and discharge, treatment and reuse, and land application techniques. No action, of course, precludes conformance with existing and future regulatory constraints and allows the continuance of the present adverse effects of the existing plant. Biological treatment and discharge to a receiving stream has been considered for both the trickling filter and activatedsludge methods of treatment. Their evaluation has previously been discussed. Treatment and reuse and land application techniques have been evaluated and dismissed as being cost prohibitive.

Selection of Alternative

The economic evaluation shows that the activated sludge process has a lower capital cost but a higher capital cost plus 20 years present worth of operation and managment than the trickling filter process. Thus, there is not a clearly defined cost advantage of one system over the other. It is shown, however, that rehabilitation for infiltration/inflow is cost effective. The evaluation indicates that it is not desirable to construct a new treatment facility at a location farther north.

Adaptability of the processes, both for staged construction and upgrading for future effluent standards, clearly favors activatedsludge over the trickling filter method of treatment.

Environmental considerations, as with adaptability, also show that the activated sludge method of treatment is the most effective.

The recommended wastewater management plan for the City of Sheridan consists of the following:

Infiltration/Inflow-

The City should initiate a request for an EPA grant increase for infiltration/inflow corrections to the existing collection system. Upon approval of the grant increase, a Step 1 (Phase 2) program would be conducted. This program would be completed in two parts - (1) physical research and investigation, television inspection and cleaning; and (2) physical rehabilitation, television inspection and sealing.

Wastewater Treatment and Disposal -

The City should proceed with a program to expand the present wastewater treatment facility. This program should consist of upgrading the present unit treatment process and converting the present trickling filter process to the activated sludge method of treatment. The present sludge disposal system should be replaced with the composting system. The feasibility and reliability of the composting system is based on the recommendations of Western Minerals, Inc. in their report "Sludge Study for the City of Sheridan, Wyoming," August 8, 1975, which was prepared by them in conjunction with this study.

Sludge Handling Alternatives

Sludge handling alternatives considered in the course of the Sheridan study were as follows:

Vacuum filtration of primary and final clarifier, sludge, disposal to land fill. (existing mode of operation)

Capital Cost = $201,000
Annual O & M Cost = $ 41,450

Aerobic digestion of primary and final clarifier sludge, vacuum filtration and disposal to land fill.

Capital Cost = $370,000
Annual O & M Cost = $ 51,900

Construct sludge holding tank for primary and final clarifier sludge, vacuum filtration and disposal to land fill.

Capital Cost = $221,000
Annual O & M Cost = $ 41,450

Direct composting of primary and final clarifier sludge, sell or distribute to consumer.

Capital Cost = $151,000
Annual O & M Cost = $ 41,325

Big Horn and Story

Existing Wastewater Systems

The unincorporated communities of Big Horn and Story maintain no central wastewater facilities, collection or treatment, and depend entirely on private disposal systems, such as septic tanks and leach fields.

Alternatives - Big Horn and Story

The unincorporated communities of Big Horn and Story were analyzed utilizing the same five basic methods for wastewater treatment as used for Clearmont, Dayton, Kaycee, and Ranchester, as well as a sixth alternative of no action. This alternative considered the continuing use of privately owned waste disposal systems. Inasmuch as the groundwater level in the communities is near the ground surface, this program is vulnerable from the standpoint of potential groundwater contamination. In fact, the Department of Environmental Quality's standards prohibit the use of subsurface tile drain fields in soils where the groundwater table is less than four feet below the surface of the ground. It is believed that the groundwater table at Big Horn and Story is generally more than four feet below the surface. The continuing use of private disposal systems would, therefore, be an acceptable course of action provided that the systems are in conformance with the requirements of the Department of Environmental Quality.

Assessment of Alternatives for Big Horn

The economic evaluation of the centralized waste treatment alternatives is made on the twenty-year present worth of the alternatives for total capital cost and annual operation and maintenance costs. The relative economic rankings of treatment alternatives are shown in Table 82.

TABLE 82

Present Worth of Treatment Alternatives[1]

Alternatives	Cost
3-Cell Conventional Stabilization Pond	
Capital Cost	
Construction Cost	$ 144,100
Incidental Costs	36,000
	$ 180,100
Present Worth of operation & maintenance cost	121,400
Total Present Worth:	$ 301,500
3-Cell Controlled Discharge Pond	
Capital Cost	
Construction Cost	$ 240,300
Incidental Costs	60,100
	$ 300,400
Present worth of operation & maintenance cost	204,400
Total Present Worth:	$ 504,800
3-Cell Aerated Lagoon	
Capital Cost	
Construction Cost	178,700
Incidental Costs	44,700
	$ 223,400
Present worth of operation & maintenance cost	191,900
Total Present Worth:	$ 415,300
Land Application	
Capital Cost	
Construction Cost	194,000 (avg.)
Incidental Costs	48,500
	$ 242,500
Present worth of operation & maintenance cost	185,000
Total Present Worth:	$ 427,500
Extended Aeration	
Capital Cost	
Construction Cost	197,500
Incidental Costs	49,400
	$ 246,900
Present worth of operation & maintenance cost	381,500
Total Present Worth:	$ 628,400

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[1] Land costs not included

Source: PRAPO EPA 208 Wastewater Facility Planning, Johnson and Sheridan Counties, 201 Facilities Plan Interim Report, pp. V-11 and 12.

The cost of constructing a wastewater collection and trunk line system is equally relevant to each of the centralized treatment alternatives considered. This cost will not, therefore, affect the rankings of the five treatment processes analyzed but must be considered in the evaluation of continued use of private facilities. Inasmuch as it was beyond the scope of work of the facilities plan to provide a detailed collection system layout plan, an idealized equivalent system with collection mains serving the area at 600-foot intervals along the trunklines was utilized. The estimated costs for constructing a wastewater collection system are as follows:

TABLE 83

Estimated Capital Costs

Big Horn Wastewater Collection System

Line	Costs
Little Goose Trunk Line	$ 162,500
Trunk Line A	87,500
Trunk Line B	18,800
Trunk Line C	81,200
Trunk Line D	31,200
Trunk Line E	62,500
Trunk Line F	37,500
Trunk Line G	68,800
Trunk Line H	43,800
Collection Mains	2,828,200
Total Construction Cost	$3,442,000
Incidental Costs	684,000
Total Capital Cost	$4,106,000

Source: PRAPO EPA 208 Wastewater Facility Planning, Johnson and Sheridan Counties, 201 Facilities Plan Interim Report, VTN Engineers, Planners, Surveyors, p. V-10

Environmental Assessment

The impact of the treatment alternatives in all cases results in an improvement to the environment by alleviating the potential of deterioration of both surface and ground water quality. The exceptions are that during periods of extreme cold the conventional stabilization pond would not produce an effluent meeting EPA standards and both the stablization pond and land application processes would periodically produce odors. The alternative of upgrading individual facilities to assure compliance with water quality standards would definitely have a positive impact upon the environment.

Selection of Alternative for Big Horn

The evaluation shows that, recognizing environmental and social considerations, the most cost-effective means of meeting the established water quality objectives is to upgrade the existing private systems and control the construction of new systems in order to assure compliance with water quality standards. The cost of such a program could range from no cost to $1,500 or more per residence for upgrading existing systems and up to $2,500 per residence for new construction.

With the present unincorporated status of the community, Big Horn residents will be compelled to finance any wastewater facilities individually. If a majority of the residents elect to incorporate, form a water and sewer district, or become part of a county-wide district, funding for wastewater treatment facilities could be from bonds or governmental assistance programs which might be available.

The costs whereby individual owners would upgrade their present facilities as required and new construction would be controlled to meet water quality standards range from zero to $1,500 each for existing facilities and up to $2,500 for new facilities. For comparison purposes, the maximum cost situation is evaluated, i.e., considering all existing facilities as being upgraded at a cost of $1,500 per residence and all new facilities being constructed at a cost of $2,500 each.

The following tabulation compares the costs of such a program with the cost of the lowest ranking treatment alternative.

Alternative 1 - Conventional Stabilization Pond	
Treatment Facility	$ 180,100
Collection Facility	4,106,000
	$4,286,100 or $3,800 per capita
Alternative 6 - No Action	
Upgrade Existing Facilities (386/3.5) @ 1,500	$ 165,400
Construct New Facilities (744/3.5) @ 2,500	531,400
	$ 696,800 or $600 per capita

Assessment of Alternatives for Story

The economic evaluation of the centralized waste treatment alternatives was formulated on the twenty-year present worth of the alternatives for total capital cost and annual operation and maintenance costs. The present worth of annual operation and maintenance costs is based on an interest rate of 6 1/8 percent for a term of twenty years. The relative economic rankings of treatment alternatives are shown in Table 84.

The cost of constructing a wastewater collection and trunk line system is equally relevant to each of the centralized treatment alternatives considered. This cost will not, therefore, affect the rankings of the five treatment processes analyzed but must be considered in the evaluation of continued use of private facilities. The subsurface soil conditions for the Story area are complex and highly erratic, thus making it extremely difficult to plan a wastewater collection system without an exceptionally detailed study. For the purposes of this study, a trunk line system to serve a centralized waste treatment consisting of a north and south trunk line was evaluated. An idealized system with collection mains serving the area at 500-foot intervals along the trunk lines was utilized. Due to the subsurface soils conditions previously described, estimating construction costs of a wastewater collection system with any degree of accuracy is all but impossible. Therefore, for comparison purposes, a factor of 167 percent was applied to known costs for similar construction under difficult conditions in the area. The resulting cost estimate is shown in Table 85.

TABLE 84

Present Worth of Treatment Alternatives[1]

Alternatives	Cost
3-Cell Conventional Stabilization Pond	
Capital Cost	
Construction Cost	$ 134,400
Incidental Costs	33,600
	$ 168,000
Present worth of operation & maintenance cost	82,900
Total Present Worth:	$ 250,900
3-Cell Controlled Discharge Pond	
Capital Cost	
Construction Cost	220,400
Incidental Costs	55,100
	$ 275,500
Present worth of operation & maintenance cost	182,800
Total Present Worth:	$ 458,300
3-Cell Aerated Lagoon	
Capital Cost	
Construction Cost	170,000
Incidental Costs	42,500
	$ 212,500
Present worth of operation & maintenance cost	191,900
Total Present Worth:	$ 404,400
Land Application	
Capital Cost	
Construction Cost	183,400 (avg.)
Incidental Costs	45,900
	$ 229,300
Present worth of operation & maintenance cost	178,200
Total Present Worth:	$ 407,500
Extended Aeration	
Capital Cost	
Construction Cost	177,800
Incidental Costs	44,700
	$ 222,500
Present worth of operation & maintenance cost	381,500
Total Present Worth:	$ 604,000

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[1] Not including land costs.

Source: PRAPO EPA 208 Wastewater Facility Planning, Johnson and Sheridan Counties, 201 Facilities Plan-Interim Report, p. IX-11.

TABLE 85

Estimated Capital Costs

Story Wastewater Collection System

Line	Cost
North Trunk Line	$ 465,000
South Trunk Line	330,000
Collection Mains	3,264,000
Total Construction Cost	$4,059,000
Incidental Costs	812,000
Total Capital Cost	$4,871,000

Source: PRAPO EPA 208 Wastewater Facility Planning, Johnson and Sheridan Counties, 201 Facilities Plan Interim Report, VTN Engineers, Planners, Surveyors, p. IX-10.

Environmental Assessment

The impact of the treatment alternatives in all cases results in an improvement to the environment by alleviating the potential of deterioration of both surface and groundwater quality. The exceptions are that during periods of extreme cold the conventional stabilization pond would not produce an effluent meeting EPA standards and both the stabilization pond and land application processes would periodically produce odors. The alternative of upgrading individual facilities to assure compliance with water quality standards would definitely have a positive impact upon the environment.

Selection of Alternate for Story

The evaluation shows that, recognizing environmental and social considerations, the most cost-effective means of meeting the established water quality objectives is to upgrade the existing private systems and control the construction of new systems in order to assure compliance with water quality standards. The cost of such a program could range from no cost to $5,500 or more per residence for upgrading existing systems, and up to $6,500 for new construction. For comparison purposes, the maximum cost situation is evaluated, i.e., considering all existing facilities as being upgraded at a cost of $5,500 per residence and all new facilities being constructed at a cost of $6,500 each. These costs are based on evapo-transpiration fields for the ultimate disposal of effluent. These types of fields utilize considerable amounts of construction material (sand and gravel). The following tabulation compares the costs of such a program with the cost of the lowest ranking treatment alternatives.

Alternative 1 - Conventional Stabilization Pond	
Treatment Facility	$ 168,000
Collection Facility	4,871,000
	$5,039,000 or $5,600 per capita
Alternative 6 - No Action	
Upgrade Existing Facilities (500/3.5) @ 5,500	$ 785,700
Construct New Facilities (398/3.5) @ 6,500	739,100 $1,524,800 or $1,700 per capita

The cost of the collection system is that required to serve the entire 2-year service area as defined by the Sheridan Area Planning Agency.

Private Sewerage Systems in Unincorporated Areas

Campbell County

Small treatment facilities serve approximately 475 residents in Campbell County. These systems, with the exception of one, have been issued National Pollutant Discharge Elimination System permits. A brief summary of each of these systems follows.

Hidden Valley Estates -

The Hidden Valley Estates sewage treatment system is an extended aeration type which consists of an aeration tank, settling tank, and chlorine contact tank to discharge. It was designed to accommodate a 25,000 gallon per day flow with a biological oxygen demand (BOD) loading of 45 lb/day. The effluent is discharged into the Donkey Creek Basin.

Anderson Addition -

The Anderson Addition sewage treatment system consists of an extended aeration system. Basic units include an aeration tank, final settling chamber, and a chlorine contact tank. This system was designed to handle a flow of 12,000 gallons per day with a biological oxygen demand loading of 19 lb/day.

Heritage Village -

The Heritage Village sewage treatment system consists of a sedimentation tank, bio-disc tank, clarifier tank and contact chlorination tank. It was designed to accommodate an inflow of 80,000 gallons per day with loads of BOD_5, 250 mg/1 and suspended solids (SS) mg/1. It discharges a flow of 80,000 gallons per day with BOD, 30 mg/1 and SS, 30 mg/1.

Carson's Mobile Home Park -

The Carson Mobile Home Park sewage treatment system consists of a lift station to the plant, an aeration tank, final settling tank, contact chlorination tank, and a settling pond. The system was designed to accommodate a flow of 30,000 gallons per day with BOD loading 12-1/2 lb. per 1,000 gallons. The system discharges to a settling pond at 30,000 gallons per day. From this pond the effluent empties into Donkey Creek Basin.

Valley View -

The Valley View Addition sewage treatment system consists of a bar screen, and aeration tank, settling chamber, a chlorination tank, and a settling pond. The system was designed to accommodate 135 houses based on a 3 person occupancy and a 150 gallons GPCD wastewater flow. The current wastewater load in this area is 45 equivalent houses. This sytem does not maintain a discharge permit since the effluent is reported to be hauled by tanker truck from the settling pond.

System in the Wright Area -

The unincorporated Town of Wright, in Campbell County, contains a central sewage collection system and treatment plant. Sewage is collected by a gravity flow system with pipes ranging in size from 8 inches in diameter to 12 inches in diameter. The sewage is conveyed by this system to a main lift station located immediately north of Highway 387, which in turn delivers it to the sewage treatment plant located just north of the lift station.

The treatment facilities consist of an aerated 2-cell lagoon measuring approximately 290 feet long and 210 feet wide at the surface with a depth of 10 feet. Aeration is provided in the first cell of the lagoon by means of a 2800 CPM turbine which feeds a system of submerged grid diffusers. After passing through the second cell for settling, the sewage is chlorinated in a separate contact chamber prior to its discharge into Hay Creek.

Any of the private systems serviceable by the Gillette system should be considered for inclusion into this central system.

Johnson County

Linch -

The private Town of Linch has an existing sewage collection system which presently discharges untreated wastewater. This problem is being resolved with the construction of a total containment lagoon which is now under construction. The lagoon is scheduled to be completed by early fall, 1978, at which time the Town of Linch will no longer maintain a discharge.

Sheridan County

Fort Mackenzie Veterans Administration Hospital -

The V.A. Hospital maintains a private trickling filter secondary treatment plant comprised of the following processes: grinding, primary clarifier, trickling filter, secondary clarifier, and chlorination. The discharge is into a ditch which ultimately reaches Goose Creek north of Sheridan. The facility records a current NPDES permit, and plant improvements are presently being considered in an operation and maintenance study now being performed.

WASTEWATER COLLECTION SYSTEM
TRUNK LINE STUDIES

Introduction

The purpose of the future service area plans for the Cities of Sheridan and Buffalo was to establish basic wastewater trunk line systems for the projected five, ten and twenty year future service areas of the cities. The future service area plans, in conjuction with the wastewater treatment facility plans, provide a comprehensive twenty year wastewater system plan for the two communities.

Buffalo

Future System

The future wastewater collection facilities are divided into three basic trunk line systems. The north and south trunk line systems serve those areas of the City which are located west of Interstate 25. These facilities will be expanded as required to serve the five, ten and twenty year population growth of the community. The east trunk line system, which will serve the area east of Interstate 25, should be developed simultaneously with the construction of the third stage of the wastewater treatment facility plan. This is expected to occur in about 1990. The wastewater treatment facility plan recommends a three-stage program of upgrading the present treatment facilities to provide a three-cell aerated lagoon system which will serve the projected future growth of the community. The first two stages provide for expansion of the facility at the present site while the third stage provides for a new facility to serve the east trunk line system.

Implementation

The concept of the five, ten and twenty year service area plans is to accommodate the projected population and land use planned for those periods. Implementation of the plans can readily be geared to accommodate fluctuations in both population growth and densities. The program of implementation anticipates a fairly uniform outward expansion for the present service area to the limits of the five, ten and twenty year service areas lying north of U.S. Highway 16. The future service areas lying south of U.S. Highway 16 are expected to be almost completely developed by the end of the five year period. The wastewater treatment facility plan recommends the construction of treatment works to accommodate the future service area east of Interstate 25. This precludes development in that area until the facility plan is implemented. This is expected to be near 1990.

Estimated Costs

The estimated project costs of the future service area plan include the cost of construction as well as incidental costs for administration, engineering, fiscal and legal services and a factor for contingencies. The estimated costs are based on present day prices and do not reflect any escalation resulting from future inflation.

Future Service Area Plan[1]
Estimated Future Project Costs

Service Area Designation	Future Service Area Plan 5 Year	10 Year	20 Year	Total
North Trunk Line System	$647,200	$177,100	$116,700	$941,000
South Trunk Line System	143,100	38,600	---	181,700
East Trunk Line System	---	---	214,300	214,300
	$790,300	$215,700	$331,000	$1,337,000

Financing

Financing of the development of the future wastewater collection systems will be accomplished with both public and private funds. The costs to the City of Buffalo will be those incurred for additional outfall and interceptor lines to serve the future developed areas. The remaining costs will be borne by the developers in accordance with the subdivision ordinances of the City. Estimated costs to the City are as follows:

City of Buffalo[2]
Estimated Project Cost

North Trunk Line System	$ 42,600
South Trunk Line System	-0-
East Trunk Line System	214,300
	$256,900

The City's share of the costs of constructing the future trunk line facilities can be funded by the issuance of sewer revenue bonds. The amount of the City's share of the financing can be reduced by the amount of funding available from any program(s) of assistance which might be in effect at the time of the expansion.

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[1] Future Service Area Plan - Buffalo, VTN Engineers, Planners, Surveyors p. 2

[2] Ibid, p. 2.

Recommendations

It is recommended that the City of Buffalo proceed with a program of implementation of construction of the future service area trunk line systems. The recommended program makes maximum use of existing facilities. The program should include a constant assessment of the changing needs of the community so that implementation may be undertaken in an efficient and orderly manner.

The first step of the implementation program is to provide such modifications to the present collection system as are necessary to accommodate the future design flows.

Sheridan

Future System

The future wastewater collection facilities are divided into four basic trunk line systems. These facilities will be expanded as necessary to serve the five, ten and twenty year population growth of the community. The East Sheridan and Little Goose trunk line systems serve the future service areas lying south and east of the present service area. That area lying northwest of the present service area will be served by the Northwest Sheridan trunk line system. This system will be an entirely new system. Two alternative plans are considered for the areas lying west of the City. Under alternative plan A, this area would be served by the Big Goose trunk line system. Because of constraints on routing the Big Goose trunk line through the City to the existing treatment plant, plan A calls for construction of a new treatment facility located in Big Goose Creek at the western limits of the present service area. Plan B contemplates extending the proposed Northwest Sheridan trunk line to serve the upper terrace levels overlooking Big Goose Creek. Three lift stations would be required for plan B. The lower areas adjacent to Big Goose Creek would not be served with alternative plan B. Plan B appears to be the most feasible of the two alternatives. However, this is a decision which need not be made immediately, inasmuch as it will not be implemented until the final ten year planning period.

Implementation

The concept of the five, ten and twenty year service area plan is to accommodate the projected population and land use plans for those periods. Implementation of the plans can readily be geared to accommodate fluctuations in both population growth and densities. The program of implementation anticipates a fairly uniform outward expansion from the present service area to the limits of the five, ten and twenty year service areas. It is not anticipated that the growth east of Interstate 90 will occur until the final ten years of the planning period. Similarly, it is not expected that the Big Goose service area will develop until the same period. Improvements to expand the municipal water system to serve these areas will be a prerequisite to constructing additional wastewater facilities.

The first steps in the implementation program will be the development of the lower reaches of the East Sheridan and Little Goose trunklines and construction of a major portion of the Northwest Sheridan trunk line system.

Estimated Costs

The estimated project costs of the future service area plan include the cost of construction as well as incidental costs for administration, engineering, fiscal and legal services and a factor for contingencies. The estimated costs are based on present day prices and do not reflect any escalation resulting from future inflation. The following tabulations reflect the estimated costs for both the total system and for those costs anticipated to be borne by the City.

Future Service Area Plan [1]
Estimated Project Costs
(Total System Cost)

Alternative Plan	5 Year	10 Year	20 Year	Total
	Future Service Area Plan			
Plan A	$1,684,950	$887,500	$2,393,650	$4,966,100
Plan B	1,776,850	887,500	1,480,100	4,144,450

FUTURE SERVICE AREA PLAN [2]
ESTIMATED PROJECT COSTS
(City of Sheridan Cost)

Alternative Plan	5 Year	10 Year	20 Year	Total
Plan A	$1,485,150	$695,300	$1,389,750	$3,570,200
Plan B	1,550,050	631,550	422,950	2,604,550

The estimated annual cost to the City of Sheridan is as follows. These costs include the cost of capitalization as well as annual operation and maintenance costs. Bond debt service is based on a rate of 6 1/8 percent for 20 years.

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[1] Future Service Area Plan - Sheridan, VTN Engineers, Planners, Surveyors, p. 2.

[2] Ibid, Pg. 3.

Future Service Area Plan[3]
Estimated Annual Cost
(City of Sheridan Cost)

Alternative Plan	Future Service Area Plan 5 Year	10 Year	20 Year
Plan A	$193,900	$288,400	$529,900
Plan B	$203,100	$292,000	$389,500

Financing

The financing of the development of the future wastewater collection systems should be accomplished with both public and private funds. The costs to the City of Sheridan will be those incurred for additional trunk lines to serve the future developed areas. The remaining costs will be borne by the developers in accordance with the subdivision ordinances of the City. The City's share of the costs of constructing the future trunk line facilities can be funded by the issuance of sewer revenue bonds. The amount of the City's share of the financing can be reduced by the amount of funding available from any program(s) of assistance which might be in effect at the time of the expansion.

Recommendations

The first step of the implementation program is to initiate a program of infiltration/inflow rehabilitation in conformance with the recommendations of the wastewater treatment facility plan. This would establish, in detail, the extent to which the capacity of the present trunk line system could be utilized to accommodate future flows. It is additionally recommended that the City proceed to develop the basic trunk line systems outlined in alternative plan B. In consideration of both treatment and collection system costs, plan B represents the least cost per person served for the total twenty year program.

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[3] Ibid, p. 3

Chapter V

MANAGEMENT AND IMPLEMENTATION

INSTITUTIONAL ANALYSIS AND RECOMMENDATIONS

Management Agencies Recommended for Designation

This subsection describes the basic recommendations for governmental institutions which should be designated by the Governor of Wyoming as the management agencies for the Powder River Water Quality Plan. These recommendations are summarized in two tables. Table 86 shows all levels of governmental agencies that have actual or potential planning, administrative, monitoring, or regulatory responsibilities for water quality planning in the PRAPO area, including those Federal agencies whose full cooperation must be formally sought. The drafting of intergovernmental agreements within and among the three levels of government to implement the management plan is a necessary work item for the future.

Table 87 contains the proposed management agencies for water quality control programs in the three county area. A management agency is considered the focal point for water quality control in a specified geographical area. Once a management agency is designated by the Governor it has the responsibility to implement point sources or non-point source control programs or assure that these control programs will be implemented.

A basic recommendation of this effort concerns the assignment of overall responsibility for the supervision and coordination of the water quality management programs and the continuous updating and refinement of the water quality management plan of the PRAPO area. For reasons that will be explained later in this institutional analysis section, it is recommended that this coordination and planning responsibility be assigned to the Wyoming Department of Environmental Quality. It may be beneficial, however, for PRAPO to continue as an advisory

TABLE 86

Authorities and Responsibilities for Direct Pollution Control Activities In PRAPO Area by Pollution Category

Type of Activity	Planning	Administration and Oversight	Funding	Construction	Operating	Monitoring	Regulatory/ Enforcement
A. NON-POINT SOURCES							
Agricultural Activities	Individuals with assistance of SCC, LCD, FhMa, SCS, PRAPO, SDA and IDWC	Individuals, SCC, LCD, SDA, FhMA, and SCS	Individuals, FhMA and SCS	Individuals with assistance of SCC, LCD and SCS	Individuals	SCC, LCD, SDA, SCS, and DEQ	DEQ
Silviculture Activities (Federal Lands)	PRAPO, BLM, and FS	BLM and FS	BLM and FS	BLM, FS, and Operators	BLM, FS, and Operators	BLM, FS, and DEQ	BLM, FS, and DEQ
Silviculture Activities (Non-federal Lands)	Individuals with assistance from SFD, SCC, and LCD	Individuals or SED	Individuals or SED	Individuals with assistance from SFD, SCC, or LCD	Individuals or SFD	SFD, SCC, LCD, and SFD	DEQ
Grazing Activities (Federal Lands)	PRAPO, BLM, and FS	Grazers, BLM, and FS	BLM and FS	BLM, FS, and Grazers	BLM, FS, and Grazers	BLM, FS, and DEQ	BLM, FS, and DEQ
Grazing Activities (Non-federal Lands)	Individuals with assistance of SCC, LCD, SCS, SDA, FhMa, and PRAPO	Individuals or Wyoming State Land Office and SCC, LCD, SCS, FhMA, AND SDA	Individuals or Wyoming State Land Office, FhMA and SCS	Individuals or Wyoming State Land Office with assistance of SCC LCD and SCS	Individuals or Wyoming State Land Office	SCC, LCD, SCS, SDA, and DEQ	DEQ
Mining Activities (Federal Lands)	Operators with assistance of BLM, USGS, EPA, FS, DEQ[1] and CEQ	Operators, BLM, USGS, FS and DEQ[1]	BLM, FS and DEQ[1]	BLM, FS, Operators and DEQ[1]	BLM, FS, Operators and DEQ[1]	BLM, FS, USGS, DEQ[1] and Operators	DEQ[1], BLM, FS, USGS, and SE[2]

TABLE 86 Continued

Authorities and Responsibilities for Direct Pollution Control Activities In PRAPO Area by Pollution Category

Type of Activity	Planning	Administration and Oversight	Funding	Construction	Operating	Monitoring	Regulatory Enforcement
Mining Activities (Non-federal Lands)	Individuals with assistance of PRAPO, approval of reclamation plans by LCD and DEQ	DEQ	Individual or DEQ	Individuals or DEQ with assistance of LCD and SCS	Individuals or DEQ	LCD, SCS, and DEQ	DEQ[1] and SE[2]
Construction Activities (Federal Lands)	Leasees, EPA, and BLM or FS	Leases and BLM or FS	Leasees and BLM or FS	Leasees and BLM of FS	Leasees and BLM or FS	BLM, FS, and DEQ	DEQ, BLM and FS
Construction Activities (State and Local Governmental Lands)	State or local agency involved and PRAPO	State or local agency involved	State or local agency involved	State or local agency involved	State or local agency involved	DEQ	DEQ
Construction Activities (Private Lands)	Individuals with assistance of PRAPO and municipality or county	Individuals	Individuals	Individuals	Individuals	Municipality or county and DEQ	Minicipality or county and DEQ
Urban Runoff	PRAPO and municipalities[3]	Municipalities[3]	Municipalities[3]	Municipalities[3]	Municipalities[3]	DEQ and Game and Fish Division	DEQ
Hydrologic Modifications	PRAPO, BLM, FS, LCD, SCC, SE, SCS, C of E, BR, state and local agencies causing modifications, and individuals	BLM, FS, SCC, LCD, SE, SCS, C of E, BR, state and local agencies causing modifications, and individuals	BLM, FS, SE, SCS, C of E, BR, state and local agencies causing modifications, and individuals	BLM, FS, SCC, LCD, SE, SCS, Cof E, BR, state and local agencies causing modifications, and individuals	BLM, FS, SCC, LCD, SE, SCS, C of E, BR, state and local agencies causing modifications and individuals	Municipalities, SCC, LCD, counties, DEQ, and Game and Fish Division	Municipalities, counties, and DEQ

TABLE 86 Continued

Authorities and Responsibilities for Direct Pollution Control Activities
In PRAPO Area by Pollution Category

Type of Activity	Planning	Administration and Oversight	Funding	Construction	Operating	Monitoring	Regulatory/ Enforcement
Individual On-site Sanitary Waste Disposal Facilities	Individuals with assistance of PRAPO and DEQ	Municipalities, counties, and DEQ[5]	Individuals	Individuals	Individuals	Counties, municipalities and DEQ	Counties municipalities and DEQ
Residual Waste Disposal	PRAPO and municipalities[7]	DEQ[7]	Municipalities[7]	Municipalities[7]	Municipalities[7]	DEQ[7]	DEQ[7]
B.POINT SOURCES							
General Public Wastewater Systems (incorporated areas)	HUD, EPA, HEW PRAPO, DEQ, and municipalities[8]	DEQ and municipalities[8]	Minicipalities[8], EDA, EPA, DEQ, FhMA, HUD, and SCS[9]	Minicipalities[8]	Municipalities[8]	Municipalities[8] DEQ[10] and EPA	Municipalities and DEQ
General Public Wastewater Systems (unincorporated areas)	PRAPO and special districts[11]	Special Districts[11]	Special districts[11]	Special districts[11]	Special districts[11]	Counties, DEQ[10] and EPA	Counties and DEQ
Individual Industrial Wastewater Facilities	Individuals with assistance of PRAPO and DEQ	DEQ and ISA[12]	Individuals	Individuals	Individuals	DEQ and EPA	DEQ

TABLE 86 Continued

FOOTNOTES AND ABBREVIATIONS TO TABLE 86

[1] Pertaining to surface coal mining based on agreement between the State of Wyoming and the U.S. Department of the Interior. Apparently DEQ does not have authority to regulate or abate pollution from inactive or abandoned mining sites.

[2] If a stream location change or a water storage facility is involved in mining operation.

[3] The responsibilities for towns with less than 5,000 are with state or county highway departments.

[4] The decisions on jurisdiction were still pending.

[5] BLM and FS have solid waste management responsibilities on their lands.

[6] The counties have the same authorities as municipalities.

[7] Loans and grants from SCS are indicated to be possible.

[8] The Wyoming Department of Helath and Social Services assists DEQ by testing and analyzing water samples.

[9] Special districts include "water and sewer districts","sanitary and improvement districts", and "improvement and services districts" which are all authorized by Wyoming law.

[10] The Industrial Siting Administration is involved in large generating and conversion sites and other large industrial facilities with expected construction costs over $50,000 (W.S. 35-502.76).

BLM = (U.S.) Bureau of Land Management
BR = (U.S.) Bureau of Reclamation
C of E = (U.S.) Army Corps of Engineers
CEQ = Council on Environmental Quality
DEQ = (Wyoming) Department of Environmental Quality
EPA = (U.S.) Environmental Protection Agency
FS = (U.S.) Forest Service
FmHA = (U.S.) Farmers Home Administration
IDWC = Interdepartmental Water Conference
ISA = (Wyoming) Industrial Siting Administration

LCD = Local Conservation District
O&G = (Wyoming) Oil and Gas Commission
PRAPO = Powder River Areawide Planning Organization
SCC = (Wyoming) State Conservation Commission
SCS = (U.S.) Soil Conservation Service
SDA = (Wyoming) State Department of Agriculture
SE = (Wyoming) State Engineer
SFD = (Wyoming) State Forestry Division
USGS = United States Geological Survey

Source: Oblinger-Smith Corporation, 1977

TABLE 87

Recommended Federal/State/Local Management Agencies By Water Pollution Category

A. NON-POINT POLLUTION SOURCES	PROPOSED MANAGEMENT AGENCIES FOR WATER QUALITY CONTROL PROGRAMS
Agricultural and Grazing Activities - Non-Federal Lands	Regulatory - N/A Non-Regulatory - LCD[1]
Agricultural and Grazing Activities - Federal Lands	Regulatory - BLM & FS Non-Regulatory - N/A
Silvicultural Activities - Non-Federal Lands	Regulatory - (State Lands) State Forestry Division[2] Non-Regulatory - (Private Lands) State Forestry Division[2]
Silvicultural Activities - Federal Lands	Regulatory - BLM & FS Non-Regulatory - N/A
Mining Activities - Non-Federal Lands	Regulatory - DEQ[3] Non-Regulatory - N/A
Mining Activities - Federal Lands	Regulatory - DEQ[4], BLM & FS[5] Non-Regulatory - N/A
Construction Activities - Non-Federal Lands	Regulatory - Municipalities and Counties[6] Non-Regulatory - N/A
Construction Activities - Federal Lands	Regulatory - Applicable Federal Land Management Agency[7] Non-Regulatory - N/A
Urban Runoff	Regulatory - N/A Non-Regulatory - Municipalities
Hydrologic Modification	Regulatory - N/A Non-Regulatory - State Engineers Office
Residual Waste Disposal	Regulatory - N/A Non-Regulatory - Municipalities and Counties
On-Site Sanitary Waste Disposal[8]	Regulatory - DEQ[9] Non-Regulatory - Counties

TABLE 87 Continued

B. POINT POLLUTION SOURCES

General Public Wastewater Systems (incorporated Areas)	Regulatory - DEQ Non-Regulatory - Municipalities[10]
General Public Wastewater Systems (Unincorporated Areas)	Regulatory - DEQ Non-Regulatory - Water and Sewer District[11]
Individual Industrial Wastewater Facilities	Regulatory - DEQ Non-Regulatory - Individual Industry

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[2] State Forestry Division has responsibility for silvicultural programs and related water quality efforts on state-owned lands and is designated by Statutes to provide technical forest management assistance to private landowners.

[3] Mining reclamation plans reviewed by local conservation districts.

[4] DEQ is recommended as the designated agency pertaining to surface coal mining operations based on the adoption of the Cooperative Agreement between the State of Wyoming and the United States Department of the Interior for the Enforcement and Administration of Surface Coal Mine Regulation Standards. However, the agreement can be terminated by the State and the Federal government or when the law is no longer authorized by federal laws and regulations.

[5] If located on lands administrated by the United States Forest Service.

[6] Wyoming Highway Department and county highway departments have a major responsibility and impact through their highway construction activities.

[7] If pertains to construction concerning surface coal mining. DEQ is recommended as the designated agency.

[8] Municipalities have certain responsibilities for those remaining incorporated areas served by septic systems. See Footnote 9.

[9] DEQ cannot delegate the regulatory function for this activity but can develop cooperation agreements with local governments for specific administrative functions.

[10] Supported by technical and financial assistance from EPA and other Federal agencies as applicable.

TABLE 87 Continued

[11] If possible, the construction, administration, and operation of all public wastewater treatment systems in unincorporated areas should be the responsibility of the "water and sewer district" variety of special districts (authority by Section 41-479.1 through 41-479.57). Furthermore, an attempt should be made to limit the creation of such districts to one per county. However, no more than one additional water and sewer district should be created in counties where one or more such districts already exist. Debt financing in such water and sewer districts should be limited to special assessment debt so as not to discourage the later enlargement of the district when new areas are to be served.

Source: Oblinger-Smith Corporation, 1978

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organization to the state agency for purposes of: 1) citizen and governmental input from the local level; 2) local agency coordination and contract; and 3) minor field service and data collection for local, state and Federal agencies.

Accordingly, in review of this preliminary plan document, PRAPO and the Department of Environmental Quality should consider the desirability of such a continuing role for PRAPO, and whether or not the support exists to fund a small professional staff for the pursuit of such functions. If such a role for PRAPO is not desired or deemed feasible, the Department of Environmental Quality might provide such functions through: 1) the creation of some other informal or formal forum for interaction among the affected levels and agencies of governmental, citizens and business interests; and 2) an augmentation of its own field staff.

The basis and details of these recommendations are explained in the following section.

Description of Alternative Areawide Institutional Management Arrangements

Five general criteria were applied in the development and, then, consideration of institutional arrangements for areawide management arrangements for water quality planning in the PRAPO area. They are as follows:

Authority and Capability

Do the governmental entities that would be major components in any given areawide institutional management arrangement have the statutory authority to successfully pursue responsibilities that could be assigned, or, judgmentally, are they likely to be expeditiously granted such authority by the Wyoming Legislature (state or local entity) or Congress (federal agency) if such a recommendation is offered? If the governmental entities have the statutory authority, are they likely to have or acquire the administrative and financial capability to effectively use such authority? These two interrelated questions sharply limit the alternative institutional arrangements that need to be evaluated under the following four criteria.

Acceptability

Are the component philosophies, policies, and intergovernmental relationships in an alternative institutional arrangement likely to be politically or culturally acceptable to the citizens in the PRAPO area and to the governmental leadership at the local, state, and national level? Are citizens' rights protected? This question is crucial, as the type of citizen, financial, and intergovernmental support will determine the level of plan implementation which can be achieved.

Accountability

To what extent are the component governmental units and agencies in a particular alternative institutional arrangement accessible to, accountable to, and controlled by the affected citizenry (and their elected officials) in proportion to their stake in the outcome of governmental decisions?

Efficiency

To what extent does a particular alternative institutional arrangement achieve its water quality management responsibilities efficiently and, therefore, economically?

Equity

To what extent does a particular alternative institutional arrangement equitably distribute the costs and benefits over the affected citizenry? Are external costs and adverse impacts on other services and social objectives minimized?

The Guidelines for Areawide Waste Treatment Management Planning (August, 1975), published by the U.S. Environmental Protection Agency, provide initial assistance in narrowing the range of feasible alternative institutional arrangements by suggesting that generally there are only three basic, practical types of institutional arrangements for most areas:

1. A Single Planning and Management Agency
2. A Single Planning Agency and A Single Management Agency
3. A Single Planning Agency and Plural Management Agencies

Upon reflection, this categorization does seem appropriate not only generally, but specifically for Wyoming and the PRAPO area. Adherence to both tested principles of public administration and good planning theory strongly supports the designation of a single agency for overall planning responsibilities within a sub-state area. Fragmentation of planning responsibilities on a functional basis creates many difficulties. Fragmenting the primary planning responsibility among several agencies for one type of functional planning (water quality management) within the planning area would probably be administratively inefficient. Then too, Section 208 of the Federal Water Pollution Control Act of 1972 calls for a single areawide planning agency in each designated planning area.

On the other hand, a decentralized, but coordinated management structure is a common and acceptable institutional arrangement. The U.S. Environmental Protection Agency specifically recognizes the legitimacy of such an arrangement by noting that "In some geographical areas and in some governmental situations where the number of local units involved is small," (certainly a description of the PRAPO area) "water quality management may be decentralized...with only a coordinator at the areawide level acting as a planning and administrative mechanism to integrate local units."[1]

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[1] U.S. Environmental Protection Agency, Management Agencies Handbook for Section 208 Areawide Waste Treatment Management, Washington, D.C.: Government Printing Office, 1975, p.4.

With the acceptance of the aforementioned three-part categorization of institutional arrangements for planning and management agencies, it is now possible to subdivide that categorization into a somewhat more specific range of institutional arrangements. The following alternative structures will be analyzed in the next section of this chapter:

1. A state agency acting as the single planning and management agency.
2. A "statutory" (a general type authorized by state statute) local agency.
3. A "joint" (meaning an agency or contractual arrangement under the Wyoming Joint Powers Act) local agency acting as the single planning and management agency.
4. A state agency acting as the single planning agency and another state agency acting as a single management agency.
5. A state agency acting or the single planning agency and a local (statutory or joint) agency acting as a single management agency.
6. A local (statutory or joint) agency acting as the single planning agency and a local (statutory or joint) agency acting as a single management agency.
7. A local (statutory or joint) agency acting as the single planning agency and a state agency acting as a single management agency.
8. A state agency acting as the single planning agency with plural state management agencies.
9. A state agency acting as a single planning agency with plural state management agencies.
10. A state agency acting as a single planning agency with a combination of state and local (statutory and/or joint) management agencies.
11. A local (statutory or joint) agency acting as a single planning agency with plural state management agencies.
12. A local (statutory or joint) agency acting as a single planning agency with plural local (statutory and/or joint) management agencies.
13. A local (statutory or joint) agency acting as a single planning agency with a combination of state and local (statutory and/or joint) management agencies.

Analysis of Alternative Areawide Institutional Management Arrangements

At first glance, a consideration of the thirteen sub-categories of alternative institutional structures may seem like an overwhelming analytical task, especially when it is recognized that there are almost limitless combinations of local and state agencies that could be employed in a variety of ways under these subcategories. Actually, however, the number of practical possiblities can be sharply and quickly reduced when they are evaluated according to the five criteria established for that purpose indicated earlier in this section.

While EPA might prefer a single areawide planning and management agency, it is also acutely aware that political acceptability of the plan is essential for implementation. Adaptations must be made for local attitudes and conditions. The philosophy in Wyoming and other portions of the Great Plains and Rocky Mountain West indicates that a single agency choice is not acceptable in the PRAPO area or anywhere in Wyoming. One need not move beyond the "acceptability" criterion to the possible problems under the "accountability" "efficiency" or "authority" criteria. Subcategories No. 1, 2, and 3 are not viable for this reason.

Even though the relatively small number of local governmental units might seem to encourage the selection of a single management agency, that approach also fails to be politically acceptable in the PRAPO area for the foreseeable future. The relative isolation of population centers and the resultant lack of inter-urban governmental complexity also suggests a more decentralized approach is yet appropirate. Subcategories 5, 6, and 7 fail for these reasons. Furthermore, insistence on local control of many management functions by Wyoming citizens and no resultant State of Wyoming push to supplement such local control rule out any single or exclusive state management function. Stated in another way, primary problems under the "accountability" criterion and secondary problems under the "accountability" and "equity" criteria cause a rejection of No. 4, 7, 8, and 11.

Measuring the subcategories against the "authority" aspects of the "authority and capabilities" criterion, it can be observed that there are various management functions (i.e., operation of wastewater treatment facilities) where no single type of local governmental unit has areawide authority, nor are they likely to receive it soon. Subcategories 5, 6, and 9 can be discarded for that reason. Furthermore, statutory authorization for certain management functions (i.e., approval of private wastewater treatment facilities in certain areas) are now given exclusively to a state agency with no authority for the delegation of such powers. Subcategories 9 and 12 are ruled out for that reason. Conversely, certain management functions are authorized strictly at the local level under Wyoming law (e.g., most forms of direct local land use regulatory powers) and this constitutes another reason for rejecting those subcategories with an exclusively state management role - No. 1, 4, 8, and 11.

The five major criteria could be utilized in more complex analysis to provide further reasons for rejecting most of the subcategories already eliminated, but it hardly seems necessary. Already the choice of subcategories still available for consideration has been reduced to two - No. 10 and No. 13. They have one feature in common - the reliance on multiple management agencies from both the local and state levels. The differences are that one has a state agency acting as a single planning agency and the other one looks to local government to fill that role. Since no single type of local governmental unit is given such planning authority for all portions of a county, not to mention the three-county PRAPO area, a local planning effort to be sufficient necessarily involves the joint action of all significant local governmental units as authorized by the Wyoming Joint Powers Act (W.S. Sections 9-18.7 to 9-18.20).

The decision between the two subcategories is reduced to a choice between a state or joint local agency acting as a single planning agency for a combination of local and state management agencies that implement the planning. Alternative No. 10 is recommended with the Wyoming Department of Environmental Quality delegated the responsibility for the supervision and coordination of the water quality management programs within, and continued planning role for, the PRAPO area.

At the present time there is no general or umbrella multi-county planning agency for the PRAPO area. Indeed, the creation of such planning organizations has not been a priority in Wyoming. The relatively few, large counties in the state, sparse population, and few and widely scattered municipalities may be cited as reasons why no urgency for such organizations has developed. The counties, or major county/city operation, is viewed (with some justification) as a reasonable alternative approach.

With no umbrella planning organization to assume the areawide water quality planning responsibilities, the only immediate, locally-based alternative is a single-function organization for that purpose and agency similar to PRAPO or a successor to it. Yet the support for such an organization among local officials and civic leaders does not appear to be present. Among some, it may be that the need for water quality planning ranks as a relatively low priority, but the primary concerns probably center around the costs to local governments and area citizens for maintaining a full, adequately-staffed, technically competent, continuing water quality planning function at the regional level in a sparsely settled area where growth problems are already straining local budgets and institutional arrangements.

On the other hand, indications are that leadership by the Department of Environmental Quality pertaining to the planning function, would not be mistrusted any more than any other organization treading in this very sensitive area, particularly if some sort of locally-based advisory group representing elected officials, citizen groups, and affected industries is created. This solution is recognized as a sound adaptation to areawide conditions and forms the basis for the recommendations on future role of PRAPO or its successor which are found on pages 256 and 263 of this section. The broad and adequate enabling legislation and technical expertise of its staff makes the Department of Environmental Quality the consensus selection and only logical choice as the state agency to pursue water quality planning in the Powder River area.

As indicated in the first section of this chapter, it may be beneficial for PRAPO to continue in an advisory capacity to assist the Department of Environmental Quality in the maintenance of water quality management planning in the three counties. This local function could be performed by PRAPO or an establishment of another committee by local elected officals.

As an option, Johnson and Sheridan Counties may desire to continue advisory efforts with a two county committee due to the fact that the two counties experience similar types of water quality problems. These two counties must deal with surface water problems much more extensively than Campbell County. Also, Johnson and Sheridan Counties contain more irrigated cropland. Campbell County, on the other hand, contains more strippable coal deposits than the other two counties. In short, due to similarity of water quality problems and topography in

Johnson and Sheridan Counties, these two counties may desire to provide an advisory group to assist the Department of Environmental Quality. Of course, Campbell County may also desire to provide an advisory function to this process with or without Sheridan or Johnson Counties.

The next task will be the identification of the proper combination of local and state agencies to designate the point and non-point pollution management responsibilities in this evolving areawide water quality plan. The next section will explain the recommendations for such designations.

Examination of State/Local Agency Designations to Implement the Water Quality Plan - Point Sources

Table 86, page 257, identifies local, state, and federal agencies that have some related responsibilities, in general or particular situations, and whose cooperation must be secured. Table 87, page 261, has previously summarized the recommendations for designated management agencies by pollution categories.

Quite naturally a primary concern expressed by EPA and state officials is the control and treatment of point pollution sources. For this reason it is appropriate to first turn to the recommended institutional arrangement for controlling point pollution sources through wastewater treatment facilities.

All classes of Wyoming municipalities have been granted the necessary statutory authority to design, construct, and operate wastewater treatment works; accept and use grants for wastewater treatment programs; raise revenues and assess waste treatment charges; incur short and long-term indebtedness; establish reasonable pre-treatment standards for waste and refuse to accept waste not meeting such standards; and effectively manage waste treatment works and related facilities. These tasks are requirements of the Federal Water Pollution Control Act. Municipalities are the only governmental entities in Wyoming with the authority to implement wastewater treatment programs within incorporated portions of Wyoming and have long demonstrated the adequacy of their enabling legislation.

The capability of very small municipalities to effectively use such legislation is another matter. Financial assistance from the state or Federal government is an absolute necessity for the small municipaltities (and of great benefit to all sizes). Intergovernmental arrangements for the management and technical expertise of expensive and complex treatment facilities is also necessary, or at least highly desirable, for small municipalities. The Wyoming Joint Powers Act would permit the creation of joint operations among municipalities for management or any other wastewater treatment function, or the provision of such services from another municipality on a contractual basis.

The choice is more complex for operating wastewater treatment operations in unincorporated portions of Wyoming, for there are three types of special districts from which to choose. One type, the "Improvement and Service District" (18-339 to 18-377), is untested, having been authorized by the Wyoming Legislature only effective May 27, 1977. The other two types " Water and Sewer District" (41-479.1 to 41-479.57) and "Sanitary and Improvement District" (35-141 to 35-165), were both originally authorized by 1959 legislation; examples of both are found in the PRAPO area and throughout the state. None of the three types may serve incorporated areas. Thus, it is obvious that municipalities and special districts are both necessary under existing law to meet wastewater treatment requirements in Wyoming.

Combined functions may be possible with municipalities under the Joint Powers Act. Their general powers relating to wastewater treatment are quite similar, but they are authorized to serve different areas (incorporated vs. unincorporated). Therefore, a legal test may be necessary on this issue. (Section 35-148 specifically authorizes the "sanitary and improvement districts" to contract with corporations or municipalities for disposal of sewage and use of existing sewerage improvements.)

All three types of these special districts seem to statutorily meet the basic requirements of the Federal Act for constructing, operating, and maintaining wastewater treatment facilities and the related water and sewer systems. Again, management of such facilities is or will likely be beyond the capabilities of many such districts in the long run. Incorporation into a municipal system, if the district debt is not prohibitive, is both likely and a long term solution for some of the districts.

While the "Improvement and Service District" law permits that type of district to plan, construct, finance, and operate the full range of improvements required in a modern subdivision and wastewater treatment facilities, the use of the "Water and Sewer District" type is recommended wherever possible. The petition requirements for its creation are less stringent, range of debt finance alternatives broader, and unlike the other two, multi-county service areas with non-contiguous parcels are specifically authorized.

Given the absence of enabling legislation for county government, an appropriate goal might be the existence of a single "water and sewer district" in each county or even a single water and sewer district for the entire three-county PRAPO area. Of course, it would include only those portions of the county or counties requiring such point pollution control of wastewater, and such a district would surrender territory to municipal systems at the time of annexation.

Authority for incurring debt through the special assessment technique (as well as through general obligation and revenue bonds) is also given to Water and Sewer Districts (and Improvement and Sewer Districts). Thus, if the "assessment" finance technique is consistently utilized where appropriate, the expansion of a single district to encompass new urban growth throughout a county or region should be possible. Incoming property owners would not be deterred from joining by a debt-ridden district. Any existing general obligation or revenue bond indebtedness that did exist would be for the basic treatment system they too will utilize - not for the basic distribution or collection systems. (Incidently, moving towards a single "water and sewer district" should be aided by existing statutory authority for the reorganization of a "sanitary and improvement district" or a "water and sewer district.")

Finally, any discussion about controlling point sources of pollution must also designate agencies for monitoring or enforcement (regulations). Through its statutory permit, approval, and monitoring responsibilities, the Wyoming Department of Environmental Quality apparently has adequate regulatory authoity to oversee the treatment facilities throughout the state. Furthermore, it has adequate powers to regulate industrial discharges occurring outside a public system through its discharge permits and standards.

Care must be taken that an adequate staff is maintained to assist and monitor the municipal and special district personnel who have the initial responsibility within their respective jurisdictions. Municipalities and special districts may require reasonable pre-treatment conditions for sewer users to protect system facilities.

Municipalities also have related enforcement powers within their boundaries. Through zoning (W.S. Sections 15.1-83 to 15.1-91) and subdivision (W.S. Sections 15.1-80 to 15.1-82)regulatory powers , municipalities can avoid approving developments which cannot be conveniently served by sewers. County governments have similar powers in unincorporated areas if they choose to use them. Through zoning (W.S. Sections 18-289.1 to 18-289.9), subdivisions (W.S. Sections 18-289.10 to 289.24), and sanitary district zoning (W.S. Sections 18-281 to 18-289), counties can avoid authorizing developments which would require public sanitary sewerage systems, but which cannot be readily provided at a particular time. Their approval authority is the keystone power for implementing a single, county-wide or multi-county "water and sewer district."

Examination of State/Local Agency Designations to Implement the Water Quality Plan - Non-Point Sources

The ultimate non-Federal authority for controlling all non-point sources of pollution to Wyoming waters is the Wyoming Department of Environmental Quality. Table 87 recognizes that primary responsibility. While the Department may and does involve some of the state's political subdivisions in its regulatory programs, the basis for such regulation traces back to W.S. Section 35-502.18. That section, enacted as a Part of the (Wyoming) Environmental Quality Act of 1973, authorizes the department to require every person to seek a departmental permit whenever such person shall:

"(i) Cause, threaten or allow the discharge of any pollution or waste into the waters of the state;
(ii) Alter the physical, chemical, radiological, biological or bacteriological properties of any waters of the state;

(iii) Construct, install, modify or operate any sewage system, treatment works, disposal system or other facility, capable of causing or contributing to pollution;

(iv) Increase the quantity or strength of any discharge;

(v) Construct, install, modify or operate any public water supply."

The Department has begun to implement such broad statutory authority by enacting rules and regulations covering such areas as basic water quality standards; control of active mining operations (including provisions that relate to surface and groundwater quality); certification of water and wastewater systems operators; spillage of oil and hazardous material; surface water protection in gas and oil production operations; solid waste management (including provisions that relate to surface and groundwater quality); construction, installation, or modification of public water supplies and wastewater facilities; and point source waste discharges.

Again, it should be noted that having the authority to control and effectively utilizing such power may be two different things. This is especially difficult in the area of non-point source pollution control where regulation is: 1) often the most difficult to monitor and enforce; and 2) the least acceptable to the affected property owners. The regulation of individual septic systems is generally as efficient or inefficient as county building inspection (if in existence) or the subdivision regulatory system.

Pollution control from agricultural and grazing activities is a particularly difficult problem to assess and address - both because of the enormity of the task and attitudes toward regulation of such activities. As in most states, for the immediate future, Wyoming will probably rely almost exclusively on increased educational and technical assistance programs delivered through the State Conservation Commission with the assistance of local conservation districts, the U.S. Soil Conservation Service, the Wyoming Department of Agriculture, and DEQ staff. Silvicultural source management is also difficult to implement. The State Forestry Division, with cooperative assistance from the U.S. Forest Service, the State Conservation Commission and local conservation districts, is the primary agency source for water pollution control implementation.

Early detection and monitoring of innumerable general locations where non-point pollution is occurring constitutes a totally impossible task for the Department of Environmental Quality or any other enforcement agency without energetic cooperation and support from a host of local, state, and federal agencies that have related responbilities. As Table 86 indicates, this is certainly true of such non-point pollution categories as construction activities, hydrologic modification, groundwater pollution, residual waste disposal, mining activity, and urban runoff.

The first effort in any pollution control program should consist of a "prevention" element with emphasis to avoid creating sources of pollution wherever possible. Land use regulations and the adoption and enforcement of building codes are extremely important. These powers provided to municipalities and counties in Wyoming, if utilized, can do a great deal to minimize urban runoff construction pollution, inappropriate hydrologic modification, residual waste disposal problems, and septic system difficulties. This is especially true in the rural portions of an area and the urbanizing fringe of communities, both of which are subject to county zoning and subdivision control if a county chooses to use such tools.

Zoning can be utilized to guide land uses to compatible, pollution-minimizing locations and to phase appropriate development for the economical and effective provision of water and sewer services. Proper subdivision control is a crucial process if new development is to: 1) minimize urban runoff, groundwater pollution, and inappropriate hydrologic modifications; and 2) be served by adequate sewage treatment systems.

Summary of Recommendations Pertaining to Local Management Agencies

Based on the previous analysis in this chapter, this section summarizes recommendations pertaining to controlling major sources of point and non-point source pollution on a county by county basis.

Campbell County

Table 88 shows the recommended management agency responsibilities and implementation schedule for controlling point source pollution through the utilization of wastewater treatment facilities.

TABLE 88

Campbell County Designated Agencies for Point Source Management of Public Wastewater Treatment Systems

System	Responsibility					
	Management			Regulatory		
	1977	1977-1983	1995-2000	1977	1977-1983	1995-2000
Gillette Waste-treatment Facilities	Gillette	Gillette	Gillette	DEQ	DEQ	DEQ
South Gillette Water and Sewer District Facilities[1]	S.Gillette W&S Dist.	Gillette	Gillette	DEQ	DEQ	DEQ
Wright Water and Sewer District Facilities	Wright W&S Dist.	Wright[2] W&S Dist.	Wright[2] W&S Dist.	DEQ	DEQ	DEQ

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[1] Do not presently maintain collection or treatment system.

[2] If Wright becomes incorporated as a municipality, it should be designated as the management agency.

Source: Oblinger-Smith Corporation, 1977

As indicated in Table 88, the City of Gillette should be designated as the agency to construct improvements and operate and manage waste treatment facilities in the Gillette area. In the very near future a trunk sewer line will be constructed to serve an incorporated area south of the City of Gillette encompassed by the South Gillette Water and Sewer District. The district is planning to construct a collection system which will feed into the trunk line and, in turn, carry sewage into the Gillette treatment facility.

It is recommended that the South Gillette Water and Sewer District be designated as the management agency for the short range. However, by the year 1983 the system should be incorporated into the existing system of Gillette. This unincorporated area could be annexed to the City of Gillette by that time. Consequently, it is recommended that Gillette be designated as the management agency after a period of 4 to 5 years. The Department of Environmental Quality would be designated as the regulatory agency.

The recently established Wright Water and Sewer District is recommended to be designated as the management agency pertaining to the improvement, operation and management of their facilities at the present time and in the future. The Department of Environmental Quality should perform monitory and regulatory functions pertaining to this district's facilities.

The non-point sources that the City should logically control are urban runoff, pollution from residual waste disposal (solid waste management) and construction activities. As related to other non-point sources, the City and County maintain a number of implementation tools that control land uses which in turn lead to maintenance of water quality in the City and the County. The City and County have adopted zoning regulations applicable in the City of Gillette and a planning district surrounding the City. Subdivision regulations are applicable to the total area within the City and the County.

The City and County have adopted a uniform plumbing code which provides comprehensive regulations concerned with private sewage systems. This code is effective within the planning district and all platted subdivisions in the remainder of the County. Mobile home park regulations are effective in the unincorporated portions of the county with permits being issued for mobile home parks in the City. The City has adopted regulations relating to floodplain management which controls development in the 100-year floodplain.

All of these tools will assist the maintenance of water quality from non-point sources of pollution in the City and County. These local governments should continue to be the management agencies for controlling land uses and construction on the land. In the maintenance of land use controls, the City and County should update zoning and subdivision regulations and consider enforcement of zoning and regulations in all portions of the unincorporated areas of the County.

The County should consider the adoption of a sediment control ordinance and regulations pertaining to water well construction and inspection.

The establishment of new regulations mentioned above and updating of existing regulations should be undertaken as soon as possible, but no later than 1983.

Johnson County

The Cities of Buffalo and Kaycee are the only public jurisdictions that maintain waste treatment facilities in the county. These two municipalities respectively should be designated as management agencies for improving, operating, and managing their waste treatment facilities. The Wyoming Department of Environmental Quality should be designated as the monitoring and regulatory agency pertaining to the regulation of municipal waste treatment facilities. These recommendations are shown in Table 89.

As related to non-point sources, it is recommended that the incorporated municipalities also should be designated as the management agencies as related to pollution from urban runoff, residual waste disposal (solid waste management) and construction activities within their respective jurisdictions. With respect to potential pollution from solid waste management, this may also be a county responsibility.

TABLE 89

Johnson County

Designated Agencies

Point Source Management

of Public Wastewater Treatment Systems

System	Responsibility					
	Management			Regulatory		
	1977	1977-1983	1995-2000	1977	1977-1983	1995-2000
Buffalo Wastetreatment Facilities	Buffalo	Buffalo	Buffalo	DEQ	DEQ	DEQ
Kaycee Waste-treatment Facilities	Kaycee	Kaycee	Kaycee	DEQ	DEQ	DEQ

Source: Oblinger-Smith Corporation, 1977

As related to other non-point sources in Johnson County and in the two municipalities, adoption and implementation of a number of land use and related controls would provide assistance in the maintenance of water quality. The County maintains an adopted subdivision resolution and a mobile home park development resolution at the present time. The County could adopt and maintain zoning controls, floodplain management controls, plumbing/sanitation codes (controlling septic tank construction and maintenance), and building codes. It appears that one of the pressing needs in the County at the present time is the establishment of controls concerning the construction and maintenance of septic tanks, and possibly regulations concerning water well construction and maintenance. This is probably the top priority item in controlling non-point source pollution in the County.

A plumbing/sanitation code should be adopted and enforced in the near future. The municipalities and the County should consider adopting the other regulations mentioned above prior to 1983.

In the end result, the two municipalities and the County are the logical management agencies for controlling non-point sources of pollution through the adoption and enforcement of a number of local regulations concerning land use and construction activities.

Sheridan County

The incorporated municipalities in Sheridan County should be designated to improve, manage, and operate their respective waste treatment facilities. At the present time the Southside Water and Sewer District maintains a collection system but does not maintain sewage treatment facilities. Sewage generated in the Southside Water and Sewer District is treated at the Sheridan waste treatment facility.

It is recommended that during a short range time period the District be designated as the management agency. Over a five year period the City of Sheridan should become the management agency for the present system and the District system should be incorporated into the City system.

The Department of Environmental Quality would be the designated agency pertaining to the regulatory functions in the management process. These recommendations are shown in Table 90.

Point pollution sources generated from individual industrial waste water facilities are controlled by the Wyoming Department of Environmental Quality. Consequently, this Department should be designated as the management and regulatory agency pertaining to these activities.

TABLE 90
Sheridan County
Designated Agencies
Point Source Management
of Public Wastewater Systems

System	Responsibility					
	Management			Regulatory		
	1977	1983	1995-2000	1977	1977-1983	1995-2000
Sheridan Waste-treatment Facilities	Sheridan	Sheridan	Sheridan	DEQ	DEQ	DEQ
Clearmont Waste-treatment Facilities	Clearmont	Clearmont	Clearmont	DEQ	DEQ	DEQ
Dayton Waste-treatment Facilities	Dayton	Dayton	Dayton	DEQ	DEQ	DEQ
Ranchester Waste-treatment Facilities	Ranchester	Ranchester	Ranchester	DEQ	DEQ	DEQ
Southside Water and Sewer District[1] Facilities	S.Side Water & Sewer District	Sheridan	Sheridan	DEQ	DEQ	DEQ

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[1] Maintains collection system only-sewage treated at the Sheridan Treatment Facility.

Source: Oblinger-Smith Corporation, 1977

In relation to the operation and maintenance of the municipal waste treatment facilities in Sheridan County, it was projected in the facilities plan that approximately one half man-year would be required to operate and maintain each of the treatment facilities of Ranchester, Dayton, and Clearmont. It is recommended that Ranchester and Dayton consider employing one full-time person to oversee the operation and maintenance of both municipalities' waste treatment facilities. This could be accomplished through a joint inter-governmental agreement established between the two Towns for this purpose.

If a half-time position is required to oversee the operation and maintenance of the treatment facility at Clearmont, the community could employ a person on a one half time basis or perhaps by inter-governmental agreement could obtain the services from the City of Sheridan. It may be more feasible to obtain the services from the City of Sheridan due to the fact it may be difficult to obtain a part-time operator for Clearmont.

These incorporated municipalities also should be the designated agencies pertaining to controlling pollution occurring from urban runoff, residual waste disposal (solid waste management), and construction activities within their jurisdictions. Potential pollution from solid waste disposal should be controlled by Sheridan County if that activity occurs in unincorporated areas.

The unincorporated communities of Big Horn and Story are served by private waste disposal systems, mainly including septic tank systems and drainage fields. Due to the fact that these communities are unincorporated and with individual systems, there is no present management agency approving, operating or managing waste treatment facilities on a unified basis in these communities. Although the facilities plans for Big Horn and Story recommended improvement of individual systems, it may be desirable in the long run to provide public wastewater treatment facilities for these two communities.

Options for providing public waste treatment systems for Big Horn and Story include incorporation of these communities or forming sewer districts under the water and sewer district laws of the State of Wyoming.

As another option, the two communities of Big Horn and Story might be served through a county-wide sewer district or a combined county-wide water and sewer district, with the district being designated as the management agency for controlling point sources of pollution in these two unincorporated communities.

As related to control of non-point sources of pollution related to development in the County, it appears that the County should consider adopting a plumbing/sanitation code for control of septic tanks.

This appears to be advantageous due to the fact that the County could provide the permits and provide maintenance of septic tank systems in these two small unincorporated areas and also undertake this function for other unincorporated areas in the County if a county-wide code is adopted and enforced on a county-wide basis. This option should be considered where unincorporated development in Sheridan County is involved.

The County maintains subdivision and mobile home regulations. Other types of activities that would aid in controlling non-point sources of pollution would be the adoption and enforcement of building codes, a sediment control ordinance, county zoning regulations, or a land use guidance system of one type or another. It appears that with the growth pressures in the unincorporated portions of Sheridan County that the County needs to take a lead role as a management agency in controlling non-point sources of pollution. The municipalities should also consider adopting these types of regulation tools where applicable pertaining to their respective jurisdictions.

As related to a time frame for these implementation activities, it is recommended that Sheridan County immediately pursue adoption of a plumbing/sanitation code for unincorporated areas. The County should consider forming a county-wide water and sewer district if public wastewater facilities are required in Big Horn, Story, or other urbanizing areas of the county. The County and municipalities should attempt to establish and enforce the other regulatory mechanisms that assist in non-point source pollution controls over the next 5 years.

Local Conservation Districts

The local conservation district in the three counties would be mainly involved in non-point source water pollution problems and most specifically in the areas of agriculture and grazing on non-federal lands, silviculture on non-federal lands in cooperation with the State Forestry Division, mining on non-federal lands, and hydrologic modification. These local districts maintain authority to review mining reclamation plans and applicants seeking to operate a mine, must seek a review of a reclamation plan from the applicable conservation district. The local conservation districts could provide data and perform advisory assistance on water quality related matters pertaining to the activities mentioned above and provide an assistance role to the State Conservation Commission. Specifically the local conservation districts are recommended to be designated as the management agency in cooperation with the State Conservation Commission pertaining to agricultural and grazing activities on non-federal lands.

Summary of Recommendations Pertaining to State Management Agencies

Table 87 in this chapter recommended state management agencies which should be designated to manage water pollution control in the three county area. The Department of Environmental Quality and its respective divisions should be designated the overall responsibility for the supervision, coordination and continuous updating and refinement of the water quality management plan in the three county area. The only exceptions to this at state level would be the designation of the local conservation district in cooperation with the State Conservation Commission to perform the management functions for agricultural and grazing activities on non-federal lands, the designation of the State Forestry Division to manage silvicultural activities on State and private lands and the designation of the State Engineers office to manage hydrologic modification activities.

In addition to its current activities related to the water quality management planning process in Wyoming, it is recommended that the Department of Environmental Quality undertake the following:

1. Provide the administrative procedures and reviews and to follow through the process to assure that the PRAPO Areawide Water Quality Management Plan is adopted as a segment of the State Water Quality Management Plan;

2. Annually review and update the PRAPO Plan;

3. Establish a mechanism specifying that all agencies designated as management agencies in the plan report annually to the Department in order to maintain an up-to-date program;

4. After five annual plan reviews and updates, the Department of Environmental Quality should prepare a five-year report concerning implementation leading toward the overall long range water quality management planning program of the state;

5. Strongly exercise its powers specified in the Adoption of the Cooperative Agreement Between the State of Wyoming and the United States Department of the Interior pertaining to controlling surface coal mining operations in the three county area. The Department should take a lead role in assuring that all mining operations on private and federal lands be regulated consistently to protect the waters in the three county area;

6. Establish procedures concerning irrigation discharge permits if that becomes a requirement in future years;

7. Provide strong leadership in assisting with public participation in the three county area related to water quality management problems, especially if PRAPO is not in existence after the initial planning effort or if an advisory committee does not continue in assisting in the on-going planning function for the area;

8. Continue or sponsor a strong water quality data collection and monitoring program in the three county area. The monitoring program should focus on stream segments with the greatest water quality problems and priority given to monitoring groundwater in mining areas. Permanent stations should be established or monitored on a scheduled periodic basis;

9. Clarify, either through new legislation or regulations of the Department, the continuing responsibility for maintenance of private waste water facilities (package treatment plants).

These recommendations should be considered for implementation over the next five year time frame.

Other recommended activities that may require new legislation include the following:

1. The provision of water quality staff in the three county area (preferably Sheridan) to assist the three counties in protecting their surface and groundwater;
2. The registration of or the establishment of water testing laboratories in Sheridan for both bacterial and chemical testing purposes;
3. Action leading to state licensing of well drillers in the State of Wyoming;
4. New legislation in Wyoming authorizing State grants and loans for improvements to general public wastewater treatment systems. This program has been utilized in other states and is particularly useful when emergency improvements are needed for waste treatment facilities or when EPA funding is not necessarily available at certain times when improvements are required.

Summary of Recommendations Pertaining to Federal Management Agencies

As indicated in Table 87, it was recommended that the Bureau of Land Management and the United States Forest Service be designated as the Federal Agencies directly responsible for pollution control activities on federal lands in the three county area. With respect to federal forest lands, the Forest Service prepares Unit plans which define this agency's efforts and goals for each national forest for a specified time in the future. Cooperative agreements among EPA, BLM, and the U.S. Forest Service indicate that water quality planning is similar in design and scope to the unit and State management framework planning process. The Bighorn National Forest Unit Plan should contain water quality sections consistent with the three county Water Quality Management Plan and the continuing planning efforts of the Wyoming Department of Environmental Quality. The Unit Plan for the Bighorn National Forest should be completed within five years or earlier and should be coordinated directly with the five-year report of the Department of Environmental Quality pertaining to water quality management planning in the State.

The Bureau of Land Management maintains a major responsibility for water pollution control activity in lands administered by that agency. The multi-purpose land use planning of BLM should be coordinated closely with the planning and enforcement of DEQ pertaining to mined land areas. This agency as well as the Forest Service mentioned above should schedule their planning programs and coordinate them as closely as possible with program outputs of the Department of Environmental Quality. Section 313 of P.L. 92-500 requires that the Federal government having jurisdiction over any property or facility or engaged in any activity resulting or which may result in the discharge or runoff of pollutants shall comply with Federal, State, interstate and local requirements respecting control and abatement of pollution. As a note, cooperative signed agreements exist at the present time between the U.S. Forest Service, the Bureau of Land Management and the County Commissioners in Johnson County.

The Environmental Protection Agency should provide funding for water pollution control and grants for construction of general public wastewater systems in incorporated and unincorporated areas. It is imperative that the Federal agencies involved in the three county area, particularly EPA, BLM, and United States Forest Service, work closely together on planning for pollution control as well as program implementation for this activity. EPA should be as responsive as possible to the Department of Environmental Quality in providing technical and financial assistance in carrying out its responsibilities.

FINANCIAL ANALYSIS AND RECOMMENDATIONS

Existing Financial Framework

The existing wastewater facility financial framework, for each of the three counties and the cities and towns therein, is reviewed in terms of the sources of funds and the types of costs to be borne. Table 91 describes the current situations with regard to each of these parameters:

TABLE 91

Existing Financial System

	Source of Funds								
	Federal			State			Local		
Jurisdiction	Planning	Capital	O&M	Planning	Capital	O&M	Planning	Capital	O&M
Johnson County				X					
Buffalo	X						X	X	X
Kaycee	X						X	X	X
Sheridan County				X					
Sheridan	X						X	X	X
Clearmont	X						X	X	
Dayton	X						X	X	X
Ranchester	X						X		X
Big Horn	X								
Story	X								
Campbell County				X					
Gillette	X	x					x	x	x

Source: Camp, Dresser, McKee, Inc., 1977

A review of the above Table and local budget and planning documents leads to the following conclusions:

1. Direct county participation, on the financial level, has not existed. However, the counties, through their public health and land use planning roles, have made a financial contribution in the regulatory area.

2. State efforts have also been primarily limited to the regulatory area, though through the state grant priority systems, there has been some planning contribution.

3. Local long-range wastewater facility planning, except for Buffalo, Sheridan, and Gillette, has previously been funded from Federal sources. On the other hand, short-range planning (i.e., sewer line extensions) has been completely a local cost.

4. There is, as a result of the recent facilities planning effort, an expectation that construction of needed additional waste treatment facilities will be partially funded by the Federal government. However, to date, only Gillette has received such grants.

5. Past capital outlay funding has been accomplished, by the incorporated entities, through creation of debt (revenue and general obligation bonding). In some cases, significant amounts of this debt remain to be paid.

6. Operation and maintenance costs are borne solely by the localities. In some cases these consist of user charges; in others the tax base is the same. In general, the utility concept of full-costing the service and obtaining needed revenues through charges based on use is not followed.

Table 92 presents the latest available financial data relative to the sewerage systems in the 208 planning area.

The current financial data, as shown by a review of Table 92, are neither voluminous nor well-detailed. However, several basic conclusions can be reached:

1. The larger communities appear to be suffering significant revenue shortfalls.

2. Two of the smaller jurisdictions, for which data are available, appear to be developing current surpluses from sewerage system charges.

3. Current sewerage system debt burdens do not appear onerous (with the possible exception of Sheridan).

TABLE 92

Financial Data

	O & M		Debt[8]	
Jurisdiction[1]	Costs	Revenues	Amount	Payment
Buffalo[2]	20,000	26,000	3,000	3,090
Sheridan[3]	323,800	180,000	1,150,000	N.A.
Gillette[4]	267,625	183,036	520,000	N.A.
Clearmont	N.A.	N.A.	N.A.	N.A.
Dayton[5]	29,000	15,868	160,000	10,525
Ranchester[6]	12,000	30,000	None	None
South Sewer and Water District	47,902	47,752	345,000	2,124
Kaycee	8,000	N/A	N/A	N/A

[1] Includes only incorporated jurisdictions with public sewerage systems.

[2] Date are for Calendar Year 1977.

[3] Cost is a departmental request for FY 77-78 (with collection and general expenses equally shared by water and sewer). Revenue is for 1976-1977. Debt is for 1976-1977.

[4] O & M data are for FY 77-78. Cost data include one-half of account 240 (Water/WW Maintenance).

[5] Includes both water and sewer (budget does not separate revenues or costs). Data are for May 1, 1977 to April 30, 1978.

[6] Includes water, sewer and garbage. Revenue for the latter is estimated to be $10,000. Data are for July 1, 1977 to June 30, 1978.

[7] FY 76-77 budgeted.

[8] Data consist of amount of debt from Bonded Indebtedness, State of Wyoming, December 31, 1976. Payment amounts, where available, from budget documents of jurisdictions.

Source: Camp, Dresser, McKee, Inc., 1977

Financial Needs and Alternative Financial Strategies

The facilities plans developed as an element of the PRAPO 208 program describe the financial goals shown in Table 93.

TABLE 93

Future Financial Needs[1]

Jurisdiction	Total	Local Share[2]	Time of Request	O&M Requirements (annual)
Buffalo	$ 398,000	$ 100,000	current	$ 13,200
	356,000	89,000	1980	53,000
	378,000	94,500	1990	75,400
Kaycee	none			
Sheridan	2,324,000	581,000	current	110,200
Gillette	4,191,200	1,047,800	current	219,200
Clearmont	114,000	28,500	current	14,300
	76,000	19,000	1985	16,900
Dayton	183,100	45,775	current	14,300
	77,400	19,350	1985	16,900
Ranchester	179,500	44,875	current	14,600
	131,300	32,825	1985	18,900
Story	None			
Big Horn	None			

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[1] From PRAPO 201 studies, in 1977 dollars with the exception of Sheridan (1975 dollars) and Gillette (1976 dollars).

[2] Based on Federal grant funding at 75 percent of planning, design and construction costs. In practice, this funding level, for total costs, is rarely reached. Accordingly, the amounts shown should be increased by at least 15-20 percent.

Source: Camp, Dresser, Mckee, Inc., 1977

The above figures, standing alone, are not indicative of the burden which the proposed program would place on the communities. Table 94 presents the local share capital costs (those recommended plus those in existence) and operation and maintenance costs on a per capita basis (using existing and future population figures shown in respective facilities plans).

TABLE 94

Projected Per Capita Costs[1]

	Population		Capital Costs		Annual O & M Costs	
Jurisdiction	No.	Year	Local Share	Per Capita	Total	Per Capita
Buffalo	5,400	1977	$ 100,000	$ 18.52	33,200[2]	$ 6.15
	6,500	1980	89,000	13,69	73,000[2]	11.23
	13,000	1990	94,500	7.27	95,400[2]	7.34
Sheridan	13,900	1977	581,000	41,80	361,400[3]	26.00
Gillette	18,500	1977	1,047,800	56.64	344,736[3]	18.63
Clearmont	190	1977	28,500	150.00	14,300	75.26
	243	1985	19,000	78.19	16,900	69.55
Dayton	590	1977	45,775	77.58	19,348	32.79
	780	1985	19,350	24.81	21,948	28.14
Ranchester	450	1977	44,875	99.72	20,600[4]	45.78
	735	1985	32,825	44.66	24,900	33.88

[1] In 1977 dollars with the exceptions shown in the notes to Table 93.

[2] Assumes new facility costs are totally additive.

[3] Present treatment plant costs have been deducted.

[4] Assumes present water/sewer O & M costs are equally divided.

Source: Camp, Dresser, McKee, Inc., 1977

A number of conclusions can be drawn from a study of the above table, the most important of which are:

1. In those communities where capital costs are recommended to be staged, population growth effects a significant reduction in per capita capital costs.

2. In a number of the smaller communities (Clearmont, Dayton and Ranchester) high per capita operation and maintenance costs can be expected.

3. Where significant new-term growth is anticipated (Sheridan and Gillette), spreading of capital costs (including even "ballooning" of debt) may be the preferred strategy.

Based on the previous discussion, a number of potential financial strategies can be identified. It is proposed that the following be given thorough consideration:

1. Short-term (e.g., 10 years or less) debt be increased to finance treatment works improvements in those communities where the construction is staged.

2. Operation and maintenance of public wastewater treatment facilities in Sheridan County as recommended on page 259, thus obtaining economies of scale and reducing these costs to the minimum for several of the smaller incorporated communities.

3. The local share of costs of facilities in the larger communities be funded through long-term (e.g., 20 + years) debt thereby placing some of the cost burden on those who cause the need for system expansion.

4. Sewerage systems in the larger communities be operated through separate funds, with charges designed to recover full costs ("full cost" financing of wastewater treatment by structuring tax fees to pay for costs).

5. Costs of planning (e.g., feasibility studies) for point source control be borne by the state.

6. A single water and sewer district be considered in Sheridan County for the purpose of designing, constructing and operating publicly-owned point source control facilities if these needs occur in the future.

7. The assessment district method of financing of treatment works be used by water and sewer district.

8. The State of Wyoming (Department of Environmental Quality) finance monitoring of effluents and enforcement of point source standards.

9. The state and the federal government finance educational and technical assistance activities designed to control non-point pollution sources.

10. Land use regulation and building code enforcement costs be shared by the counties and the municipalities.

11. Include debt service in ad valorem tax base.

12. Include all costs (debt service, other capital, and operations and maintenance) in a user charge system.

Each of these strategies is evaluated in Table 95.

TABLE 95

Evaluation of Alternative Financing Strategies

Financing Strategy	Evaluation
1. Use of short-term debt to finance staged treatment works improvements.	Times costs with need; permits those who caused the need to pay the associated capital costs; prevents layering of debt service payment. However, requires relatively high debt service payments.
2. Combined agency operation and maintenance of public treatment facilities in Sheridan County. (in several instances)	Reduces overhead costs; maximizes productivity of staff by reducing slack time (small plants may require only fractional manpower); reduces training time and costs (the small plants use similar technology). Requires significant travel between plants thereby adding to costs and reducing emergency response capability.
3. Funding of local share of capital costs in larger communities be handled through long-term debt.	Reduces current debt service payments thereby minimizing initial (post-construction) user charge increases; postpones a portion of the capital payments to the time when new residents/industries can assist in paying for facilities. Increases total debt service costs because of normally higher interest costs due to longer debt terms.

TABLE 95 Continued

4. Larger communities operate treatment works through separate funds, with new charges recovering full costs.	Reduces pressure on tax base; identified specifically the costs of waste treatment; places burden of costs on those who cause them and not on existing residents. Can bring about large and abrupt changes in the way costs of government are passed on to the public with possible adverse reactions.
5. State government bearing the costs of planning.	Available, trained and qualified staff capability; can provide a consistent approach state-wide. Sources of income, therefore, may not be identified and the availability of organizations for providing needed local input has not been properly studied.
6. Single agency in Sheridan County for designing, constructing and operating treatment works (if needed for the future).	Provides a potential for economies of scale; reduces potential for municipality/suburban unincorporated area conflicts; provides expanded financial base; provides an institutional and financial base for meeting unanticipated facilities needs. May not be feasible in view of the current situation and the wide variances in projected costs among the various jurisdictions.
7. Use of assessment district method.	Makes possible equal sharing of capital costs over time. Not always practicable in areas where land uses are mixed and a large percentage of the land is not expected to be placed in uses requiring public sewers.
8. State financing of monitoring and enforcement,	Sole available source; has statutory authority; provides for state-wide approach.
9. State and federal financing of non-point source educational and technical assistance.	Sole available capability (little is known about cost-effective technical methods or about proper control techniques).

TABLE 95 Continued

10. Land use regulation and building code enforcement costs be shared by counties and municipalities.	Traditionally power reserved to local governments; now being accomplished, in varying degrees.
11. Include capital facilities debt service in ad valorem tax base.	Reduces size of user charges; spreads costs of facilities over those who now use them and those who may use them in the future. However, sometimes place these costs inequitably in that use, or potential use, is often not positively related to property values.
12. Include all costs of treatment facilities in the user charge.	Probably, the most equitable approach, but often requires a high user charge. If debt service requirements change appreciably from year to year, can cause wide fluctuations in user charge rates.

Source: Camp, Dresser, McKee, Inc., 1977

As is evident from Table 95, the subject of financing is intertwined with the types of institutional arrangements finally agreed upon and implemented. Further, those financing techinques finally adopted must conform, in the case of federal grant-funded facilities, with the requirements imposed by federal law. These include:

> Imposition of user charges which fully recover costs of operation and maintenance (including replacement) from each user on the basis of use.
>
> Recovery of the federal grant portion of construction costs from industrial users (industrial cost recovery).

The details of the federal requirements are developed, in depth, in EPA rules, regulations, and guidelines. Thus, they need not be repeated here. However, the important factor is that, for those communities accepting federal construction grants, reliance on the ad valorem tax base for operation and maintenance costs will no longer be allowed. Further, some form of user charge system based on both sewage volume and amounts of pollutants (biochemical oxygen demand and suspended solids) will have to be adopted in order that the full amount of the federal grant may be received.

An additional need is for the development and implementation of the federal grant industrial cost recovery systems. Since sanitary waste (normal household sewage) discharges are exempt from this requirement, it can be anticipated that this will be a minimal requirement in the three counties.

Financing Recommendations

Based on the analysis conducted in the previous sections, it is recommended that the following financial strategies and techniques be adopted:

1. Use of short-term debt for phased facilities construction and long-term debt otherwise.
2. Use of separate funds and full cost user charges in municipalities.
3. State acceptance and bearing of costs of the monitoring, regulatory, and planning functions.
4. Local funding of land use and building code enforcement.
5. Use of the assessment district form of debt cost sharing in developed (or nearly developed) areas.
6. State and federal financing of non-point source controls.

Chapter VI

PUBLIC PARTICIPATION

INTRODUCTION[1]

Any planning and management program, no matter how well prepared, will prove useless unless it is first accepted by the people within the area affected. The 208 planning program was initiated with this realization in the minds of all the participants involved. Section 101(e) of Public Law 92-500 states that "public participation...shall be provided for, encouraged, and assisted" at Federal, State and local levels. The purpose of public participation in the water quality management process is to aid public education, create a plan sensitive to local needs and values, and build support for plan implementation. Development and emphasis of the particular public participation programs were relegated to the individual agencies; however, Federal Regulations specify that at least eight requirements be met in order to carry out the intent of Section 101(e).[2] These requirements include:

1. Making available technical and procedural materials, which will allow citizens adequate time and opportunity to study the information and make timely and informed input into the decision-making process.

2. Providing assistance to public groups for citizen education and/or training which will assist the average citizen to participate effectively in the planning program.

3. Consulting with interested citizens throughout the planning program to receive their views and opinions during all phases and prior to the formulation of any decisions.

[1] Prepared from information developed by the Powder River Areawide Planning Organization

[2] Public Participation Handbook for Water Quality Management, U.S. Envrionmental Protection Agency, p. 3 - 5.

4. Providing notification of key developments, meetings and other important dates through the use of newsletters, bulletins and the media.

5. Maintaining records of specific citizen input and agency response to it which will ensure that information and evidence from citizens gets proper consideration.

6. Providing information about legal proceedings being taken involving the planning and the ramifications of that litigation.

7. Conducting public hearings to allow the public a formal opportunity to be heard prior to any decision-making.

8. Forming advisory committees which include representatives of appropriate Federal, State and local agencies as well as the general public.

These requirements consist of minimum requirements and do not guarantee the effectiveness of a public participation program. An effective program requires that initiative be undertaken to insure that the public is fully informed of all aspects of the planning program. This includes public involvement, beginning with the preliminary discussions of the needs for a planning program, continuing through the final plan designation and into the various phases of implementation.

PRAPO PARTICIPATION PROGRAM

Within the Powder River 208 planning program, public participation was initiated at the outset with a series of public meetings in various communities to discuss the need for water quality planning in the three county area. From these meetings evolved the formation of the Powder River Areawide Planning Organization, the 208 grant application and the preliminary work plan for the two year project. News coverage by local newspapers was used throughout the preliminary phases of the project to keep the public informed. This news coverage continued throughout the life of the planning effort.

Due to budget constraints, public participation for the first six months of the project was undertaken by the project director and the water quality specialist.

In November, 1975 a Technical Advisory Committee was formed. Membership included representatives from involved Federal, State and local agencies and concerned citizens groups. The functions of this committee were to review the approach taken in instituting programs, coordinate ongoing programs within the respective agencies of members of the Technical Advisory Committee with the 208 program, and evaluate outputs of the program for technical and management feasibility.

A Citizens' Advisory Committee consisting of concerned citizens was also formed to assist in making the planning group aware of the views of the general public and reviewing outputs for their comprehensibility and acceptability by the public.

Soon after the early planning phases were initiated, a part-time public awareness coordinator was employed and the public participation program was formally organized. The public participation program included a number of different phases. A general mailing list of people who might have some interest in water quality planning in the Powder River Basin was established. Periodic newsletters were printed and distributed. These newsletters were utilized to explain the 208 program and to provide synopses of the various activities being carried out. Comments were solicited and forms were included to expand the mailing list. The planning staff participated in local radio talk shows and Bicentennial celebrations. The staff distributed literature and visited with anyone interested in seeking additional information concerning the program. Radio and television public service announcements, specifically designed to acquaint the public with the program, were distributed to the various broadcast media outlets servicing the planning area.

There were two noteworthy accomplishments of the public participation program. The first was the production of a 23 minute slide presentation which was shown to various organizations and groups. The slide presentation, accompanied by a narrative, depicted the waters of the region, pollution problems, the various potential impacts which may degrade water and the steps being taken by PRAPO to find solutions to present and potential problems.

The second major accomplishment of the public participation program consisted of the publication of a newspaper supplement which was distributed in four different newspapers throughout the three county region. The supplement was formulated by PRAPO staff, with the aid of a member of the League of Women Voters. It contained articles on the impacts on water quality caused by mining, agriculture, forestry, increased urban growth, increased rural growth and the impacts from development on federal lands. The supplement also contained a section on the suggested general approach to implementation of the water quality management program. A series of public meetings were conducted after publication of the supplement to obtain comments by the citizenry on the topics outlined in the supplement and the suggested approach undertaken by PRAPO in implementing corrective actions.

Technical and advisory committee meetings and citizens advisory committee meetings have been conducted at various times throughout the project to discuss the development of the program and the outputs generated from it. In addition, public meetings and meetings with local officials were held at various times during the two year period at different locations to discuss and receive comments on portions of the planning effort which were specific to those areas. These meetings included public hearings on facilities plans for a number of communities and meetings in Story to discuss the drinking water survey conducted by PRAPO.

Another series of public meetings will be held following publication of the draft plan, one of which will be conducted as a public hearing in conjunction with the Wyoming Environmental Quality Council.

Throughout the life of the program a library of water quality related materials has been acquired and maintained for use by the planning agency, other governmental units and concerned citizens.

Financial constraints did not allow the public participation portion of the planning effort to be as comprehensive as desired. Under these constraints, the preceding pages have related a number of different approaches utilized to obtain information from the public concerning water quality managment planning. Although results have been limited, there has been intensive citizen involvement in one or more instances. The citizens of Story participated effectively in a drinking water well survey due to their concern over the possibility that water wells were polluted by septic tank effluent.

The completion of the water quality management plan does not mean that public involvement activities are also completed. Strong efforts are required to involve the public in the implementation of the various phases of the plan. This program consists of a twenty year program which necessitates an annual updating of the plan. The public must be made aware of this and be involved in these annual updates. The public must continue to be made fully aware of their responsibilities in preserving the quality of the area's waters.

APPENDICES

SURFACE WATER QUALITY CRITERIA BY USE (1)

Constituent	Secondary Contact Recreation	Primary Contact Recreation	Stream Aesthetics	Industrial Water Supply	Agricultural Irrigation	Wildlife and Livestock Watering	Public Water Supply	Fishery
Alkalinity								>20.00
Ammonia, un-ionized (as N)								0.02
Arsenic					0.10	0.20	0.05	
Barium							1	
Beryllium					0.50			0.011(soft)(3) 1.100(hard)
Boron					0.75	5.0		
Cadmium					0.01	0.05	0.01	0.0004(soft)(3) 0.003 (hard)
Chloride						2,000	250.00	
Chlorine								0.002
Chromium					0.5	1.0	0.05	0.10
Coliform, Fecal (#/100ml)	1,000(4)*	200 (5)*						
Copper					1.0	1.0	1.0	0.1 x(6)
Cyanide							0.2	0.005
Fluoride						2.0	2.2(7)	
Iron							0.3	1.00
Lead					5.0	0.1	0.05	0.01 x(8)
Manganese					2.0		0.05	
Mercury						0.00005	0.002	0.00005

Constituent	Secondary Contact Recreation	Primary Contact Recreation	Stream Aesthetics	Industrial Water Supply	Agricultural Irrigation	Wildlife and Livestock Watering	Public Water Supply	Fishery
Nickel					0.1			0.1
Nitrate = Nitrite (as N)							10	
Oxygen, Dissolved			Aerobic					6.0* (game) 5.0 (non-game
pH (units)								6.5-8.5* 6.5-9.0
Phenol							0.001	0.001
Radioactivity (pCi/l)							3 Ra226* 10 Sr 90* 15 gross alpha	
Selenium					0.05	0.05	0.01	0.01 x (9)
Silver							0.05	0.01 x (9)
Sodium Adsorption Ratio					15			
Solids, Total Dissolved				(10)	(11)	5,000		
Solids, Total Suspended								25-80
Sulfate						3,000	250	
Temperature (Max. change in Degrees C.)								1.1 *cold H_2O 2.2 *warm H_2O
Turbidity (Max. increase in JTU)								10* (game) 15* (non-game
Zinc					5.0	25.0	5.0	0.01 x (9)

*Wyoming Water Quality Standards (1974)

(1) All criteria are in mg/l. except for pH, sodium adsorption ratio, and where specified.

(2) Agricultural irrigation criteria apply only to the May 1 - September 30 period.

(3) Soft water is defined as having 0-75 mg/l. of $CaCO_3$. Hard water is defined as greater than 75 mg/l. $CaCo_3$.

(4) During the recreation season May 1 to September 30, based on a minimum of not less than five samples taken over a thirty day period, the fecal coliform bacterial level should not exceed a geometric mean of 1000/100 ml., nor should more than 10 percent of the total samples taken during any thirty day period exceed 2,000 per 100 ml.

(5) EPA swimmable criteria to be used in considering all streams as well as those streams with primary contact recreation during the recreation season of May 1 to September 30. Based on a minimum of not less than five samples taken over a thirty day period, the fecal coliform bacterial level should not exceed a geometric mean of 200/100 ml., nor should more than 10 percent of the total samples taken during any thirty day period exceed 2,000 per 100 ml.

(6) A 96-hour LC_{50} as determined through nonaerated bioassay using a sensitive aquatic resident species.

(7) Fluoride criteria is based on the annual average of the maximum daily temperature.

(8) The 96-hour LC_{50} value, using the receiving or comparable water as the diluent and soluble lead measurements (non-filterable lead using an 0.45 micron filter), for sensitive freshwater resident species.

(9) The 96-hour LC_{50} as determined through bioassay using a sensitive resident species.

(10) Industrial requirements for TDS content of raw water is quite variable. The economics of de-ionization are the limiting factor for industry.

(11) Irrigation requirements for TDS are variable depending on soils, geology, irrigation practices, climate and types of crops raised.

APPENDIX B

WATER QUALITY STANDARDS

1974 and 1977

WYOMING WATER QUALITY STANDARDS - 1974

	CLASS I* WATERS	CLASS II* WATERS	CLASS III* WATERS
Dissolved oxygen	6 mg/L or more	5 mg/L or more	
pH	6.5 - 8.5	6.5 - 8.5	6.5 - 8.5
Fecal coliform	(1)	(1)	(1)
Oil and grease	10 mg/L	10 mg/L	10 mg/L
Dissolved solids			
Radioactive material	3pCi/L of Radium 226	3pCi/L of Radium 226	3pCi/L of Radium 226
	10pCi/L of Strontium 90	10pCi/L of Strontium 90	10pCi/L of Strontium 90
Turbidity	10 JTU (2) increase	10 JTU (2) increase	
TOTAL GAS PRESSURE	---------------------- 110% of Existing Atmospheric Pressure----------------		

Class II. Those waters which, based on information supplied by the Wyoming Game and Fish Department, are determined to be presently supporting game fish or have the hydrologic and natural water quality potential to support game fish.

Class III. Those waters which, based on information supplied by the Wyoming Game and Fish Department, are determined to be presently supporting non-game fish or have the hydrologic and natural water quality potential to support non-game fish.

Class IV. Those waters which, based on information supplied by the Wyoming Game and Fish Department, are determined as not having the hydrologic or natural water quality potential to support fish.

PROPOSED WYOMING WATER QUALITY STANDARDS - 1977

	CLASS I* WATERS	CLASS II* WATERS	CLASS III* WATERS	CLASS IV* WATERS
Dissolved oxygen	Waters in which the existing quality must be maintained; no new point source discharges will be allowed; no existing point source discharges will be allowed to increase amounts of pollutants.	6 mg/L or more	5 mg/L or more	
pH		6.5 - 8.5	6.5 - 8.5	6.5 - 8.5
Fecal coliform		(1)	(1)	(1)
Oil and grease		10 mg/L	10 mg/L	10 mg/L
Radioactive material		5pCi/L of total Radium 226 plus Radium 228	5pCi/L of total Radium 226 plus Radium 228	5pCi/L of total Radium 226 plus Radium 228
		8pCi/L of total Strontium 90	8pCi/L of total Strontium 90	8pCi/L of total Strontium 90
Un-ionized ammonia (As N) (2)		0.02 mg/1	0.02 mg/L	
Chlorine (3)		0.002 mg/L	0.01 mg/L	
Temperature		2°F (1.1°C) increase (4)	2°F (1.1°C) increase (4)	
		4°F (1.1°C) increase (5)	4°F (1.1°C) increase (5)	
Turbidity		10 NTU's increase (6)	15 NTU's increase (6)	
Total dissolved gases		110% of saturation value	110% of saturation value	

APPENDIX C

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